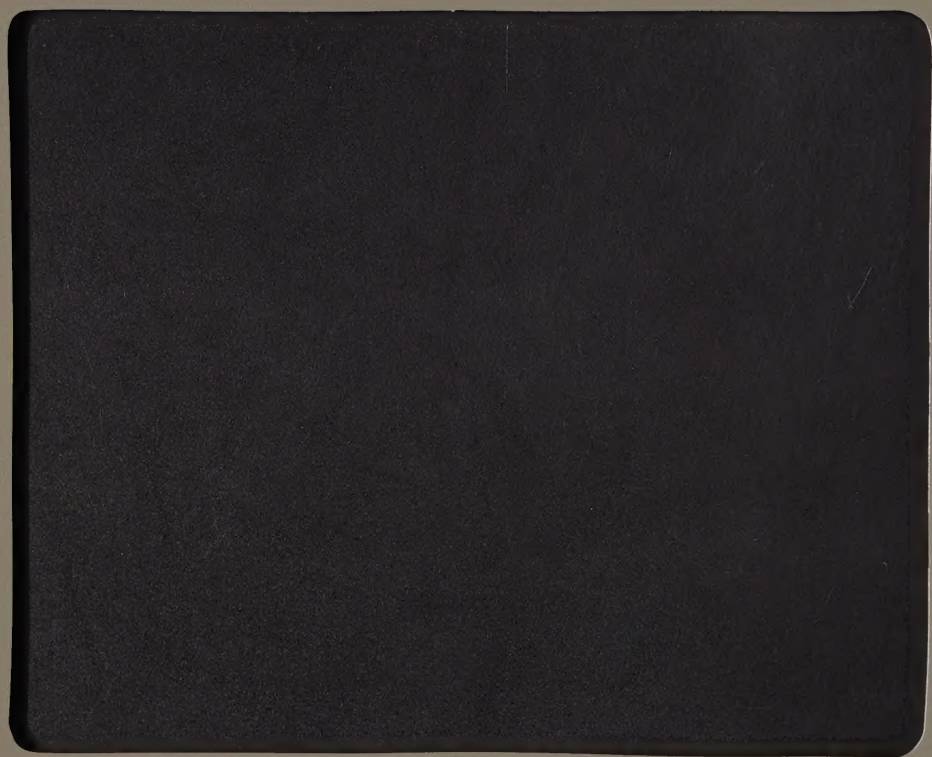


2170A

Digital Thermometer

Instruction Manual





*Calibration
Int 30 Nov 1981*

2170A

Digital Thermometer

Instruction Manual

P/N 445460
April 1976
Rev. 1 2/77



WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

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CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC., will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX 43210, MOUNTLAKE TERRACE, WASHINGTON 98043, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box 43210, Mountlake Terrace, Washington 98043

Change/Errata Information

Issue No: 3 7/79

This change/errata contains information necessary to ensure the accuracy of the following manual.
Enter the corrections in the manual if either one of the following conditions exist:

1. The instrument's pcb revision letter is equal to or higher than that which is indicated at the beginning of the change.
2. No revision letter is indicated at the beginning of the change/errata.

MANUAL

Title: MODEL 2170A DIGITAL THERMOMETER
Print Date: APRIL 1976
Rev and Date: 1-2/77

C/E PAGE EFFECTIVITY

Page No.	Print Date
1	7/79

CHANGE #1-11563
Rev J-1

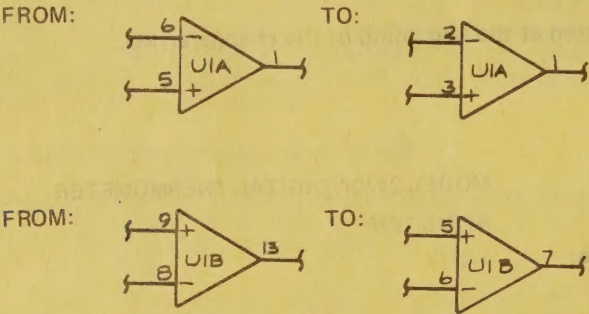
On page 5-7, make the following changes:
Change the U1 entry from:
IC, dual opnl ampl; 404087; 49956; RC4739DP; 1; 1
to:
Op amp pcb assy; 488379; 89536; 488379

Add the following new entry (socket for U1):
XU1; Socket, IC, 14-pin DIP; 276527; 89536; 276527; 1;1

Rev K

On page 5-7, change the entry for U1 from:
IC, dual opnl ampl; 404087; 49956; RC4739DP; 1; 1
to:
IC, dual opnl ampl, 8-pin DIP; 478032; 04713; MC4558NCPI; 1; 1

On page 8-3, Figure 8-2, make the following changes:



ERRATA #1

On page 4-2, make the following changes:
Replace paragraph 4-14 with the following:
4-14. If the A21-5 Voltage Divider is ordered, it should be noted that it consists of two precision resistors with no test fixture. The user will be responsible for configuring the resistors as the appropriate voltage divider.

ERRATA #2

The following information pertains only to the 2160A-04 AOU manual.
On page 604-1, paragraph 604-4, make the following changes:
FROM: Linearity ±0.5% of Full Scale
TO: Accuracy ±0.5% of reading ±1 mV

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Section 1

Introduction & Specifications

1-1. INTRODUCTION

1-2. The Model 2170A Digital Thermometer is a panel-mounting, four-digit, thermocouple thermometer capable of resolving 0.2°C or 0.2°F over a temperature range of -99.8 to +999.8°C or -99.8 to +999.8°F. It features a four digit LED display, a reference-junction compensator (to eliminate the need for an ice bath reference junction), front-panel jumper selection of °C or °F, the choice of using any one of four thermocouples types (J, K, T or E) as the input device, dual-slope measurement techniques and digital linearization of the thermocouple inputs. Several options and accessories are also available for use with the 2170A.

1-3. The front panel display consists of five, seven-segment, high-intensity LED's, and features leading-zero suppression. Four of the LED's are used to display numeric data, including a minus sign for negative temperature indications. The fifth LED displays the selected °C or °F scale character. An open-thermocouple detector causes the display to blink when an open circuit is sensed at the thermocouple input terminals.

1-4. Rear-panel, screw-type input connectors are provided for attaching the selected thermocouple. These terminals are an integral part of an isothermal block, and serve as the reference-junction for the reference-junction compensator. (The reference-junction compensator provides the physical and electrical equivalent of, and eliminates the need for, an ice bath reference junction at 0°C or 32°F.)

1-5. A jumper located behind the display lens can be positioned to select either the °C or °F temperature scale. The scale change can be made at any time and has no effect on calibration. The °C or °F LED displays the selected scale.

1-6. The actual measurement range of the 2170A is determined by the type of thermocouple being used as the input device. Any one-of-four thermocouple types can be used; J, K, T or E. To ensure the proper linearization of the selected thermocouple input, a corresponding linearization program must be selected on the interior of the unit. Selection is accomplished by installing a type select pcb which corresponds to the input thermocouple. A single type select pcb is supplied with the unit to match the thermocouple type specified at the time of purchase. The remaining pcb's are individually available as accessories and are described in Table 1-1.

Table 1-1. 2170A ACCESSORIES

MODEL NO.	DESCRIPTION
P20J	J-Type Thermocouple Probe
P20K	K-Type Thermocouple Probe
P20T	T-Type Thermocouple Probe
M00-200-611	Rack Mounting Kit, Offset
M00-200-612	Rack Mounting Kit, Center
2160A-7031	Rack Mounting Panel, one unit
2160A-7032	Rack Mounting Panel, two units
2160A-7033	Rack Mounting Panel, three units
2160A-7016	J-Type Select PCB
2160A-7017	K-Type Select PCB
2160A-7019	E-Type Select PCB
2160A-7018	T-Type Select PCB
2160A-7022	Interface Cable
2161A	Multipoint Selector
2162A	Digital Comparator

1-7. Options available for use with the 2170A are listed and described in Table 1-2. Both options are field installable. Either one, but not both, of the options can be in-

Table 1-2. 2170A OPTIONS

OPTION NUMBER	DESCRIPTION
-02	Analog Output Unit
-04	Digital Output Unit

stalled in a unit. Detailed information concerning each option is given in Section 6 of this manual, Option and Accessory Information.

1-8. The 2170A is available in any one of three line power configurations: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Specify the required configuration at the time of purchase.

1-9. SPECIFICATIONS

1-10. Specifications for the 2170A are given in Table 1-3.

Table 1-3. SPECIFICATIONS

ELECTRICAL

Compatible Thermocouple Types	Unit can be calibrated to operate with any one of the following thermocouple types: J, K, T, E
Measurement Method	Dual-slope integration over a 100 ms period
Zero Drift	None. Automatic zero correction
Reading Rate	2.5 readings per second
°C to °F Conversion	Jumper selectable
Input Characteristics	
Input Connections	Screw terminals on isothermal connector
Input Circuit	Two-wire, isolated
Input Impedance	> 100 MΩ
Input Current	< 500 pA
Source Impedance	≤ 5kΩ. 5kΩ causes < 0.2°C error with k thermocouple
Overload	Display flashes when input voltage exceeds full-scale temperature range
Open Input	Display flashes to indicate open at input terminals
Maximum Input Voltage (without damage)	400V dc or ac peak continuously between inputs or between either input and ground
Maximum Common Mode Voltage (without damage)	400V dc or ac peak
Common Mode Rejection	≥ 120 dB @ 50, 60, 400 Hz ±0.1% with 1kΩ source impedance unbalance
Normal Mode Rejection	≥ 60 dB @ 50, 60, 400 Hz ±0.1%
Accuracy	See Table 1 for °C specifications and Table 2 for °F specifications
Response Time to Rated Accuracy	< 2.0 seconds
Linearization	Digital with four selectable programs in LSI ROM
Linearization Programs	
J, K, T and E	32 straight line segments for positive inputs and 16 for negative inputs

Table 1-3. SPECIFICATIONS (Cont.)

Reference Junction Compensation

20 to 30°C (68 to 86°F)

J, K, T, E 0.025 degrees per degree

0 to 20°C, 30 to 50°C (32 to 68°F, 86 to 122°F)

J, K 0.032 degrees per degree

T, E 0.045 degrees per degree

Temperature Coefficient 0.005% of reading per °C

Internal Temperature Rise ≤ 5°C (9°F)

Table 1. ACCURACY SPECIFICATIONS °C

THERMOCOUPLE TYPE	TEMPERATURE RANGE °C	RESOLUTION AND REPEATABILITY (±°C)	APPLICABLE TEMPERATURE RANGE °C	MAXIMUM ERROR INCLUDING NBS CONFORMITY (±°C) *				NBS CONFORMITY (±°C)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 23 to 27°C	90 Days 20 to 30°C	1 Year 15 to 35°C	
J	-99.8 to 777.8	0.2	-99.8 to 0 0 to 777.8	0.5 0.4	0.7 0.5	1 0.7	1.2 1.1	0.19 0.15
K	-99.8 to 999.8	0.2	-99.8 to 0 0 to 999.8	0.7 0.5	0.8 0.6	1.2 1.1	1.5 1.4	0.2 0.18
T	-99.8 to 400	0.2	-99.8 to 0 0 to 400	0.6 0.4	0.6 0.5	1 0.6	1.6 0.9	0.19 0.15
E	-99.8 to 999.8	0.2	-99.8 to 0 0 to 999.8	0.6 0.5	0.7 0.6	1 1	1.7 1.4	0.17 0.18

*Includes reference junction and conformity errors. Excludes thermocouple errors.

Table 2. ACCURACY SPECIFICATIONS °F

THERMOCOUPLE TYPE	TEMPERATURE RANGE °F	RESOLUTION AND REPEATABILITY (±°F)	APPLICABLE TEMPERATURE RANGE °F	MAXIMUM ERROR INCLUDING NBS CONFORMITY (±°F) *				NBS CONFORMITY (±°F)
				CALIBRATION ACCURACY	20 min. to 24 hrs. 72 to 81°F	90 Days 68 to 86°F	1 Year 59 to 95°F	
J	-99.8 to 999.8	0.2	-99.8 to 32 32 to 999.8	0.9 0.7	1 0.8	1.6 1.2	2.1 1.6	0.27 0.2
K	-99.8 to 999.8	0.2	-99.8 to 32 32 to 999.8	1.1 1	1.2 1	2.0 1.4	2.6 1.8	0.28 0.26
T	-99.8 to 752	0.2	-99.8 to 32 32 to 752	0.9 0.6	0.9 0.8	1.7 1	2.9 1.5	0.3 0.2
E	-99.8 to 999.8	0.2	-99.8 to 32 32 to 999.8	0.9 0.8	0.9 0.9	1.7 1.3	3.0 1.8	0.25 0.25

*Includes reference junction and conformity errors. Excludes thermocouple errors.

Table 1-3. SPECIFICATIONS (Cont.)

GENERAL

Type of Display	LED, 0.56 in high characters.
Power Requirements	115V ac $\pm$ 10%, 50 to 440 Hz, 4W. 100V ac and 230V ac versions are also available.
Size	1.88 in (H) x 3.78 in (W) x 8.05 in (D) (4.78 cm x 9.6 cm x 20.45 cm). Conforms to DIN standard. See Figure 1-1.
Weight	1 lb. 10 oz. (0.737 kg)

ENVIRONMENTAL

Temperature	
Operating	0 to 50°C (32 to +122°F)
Storage	−40 to 75°C (−40 to 167°F)
Humidity	
0 to 50°C (32 to 122°F)	80% non-condensing
0 to 35°C (32 to 95°F)	90% non-condensing
Shock and Vibration	Meets requirements of MIL Standard 810

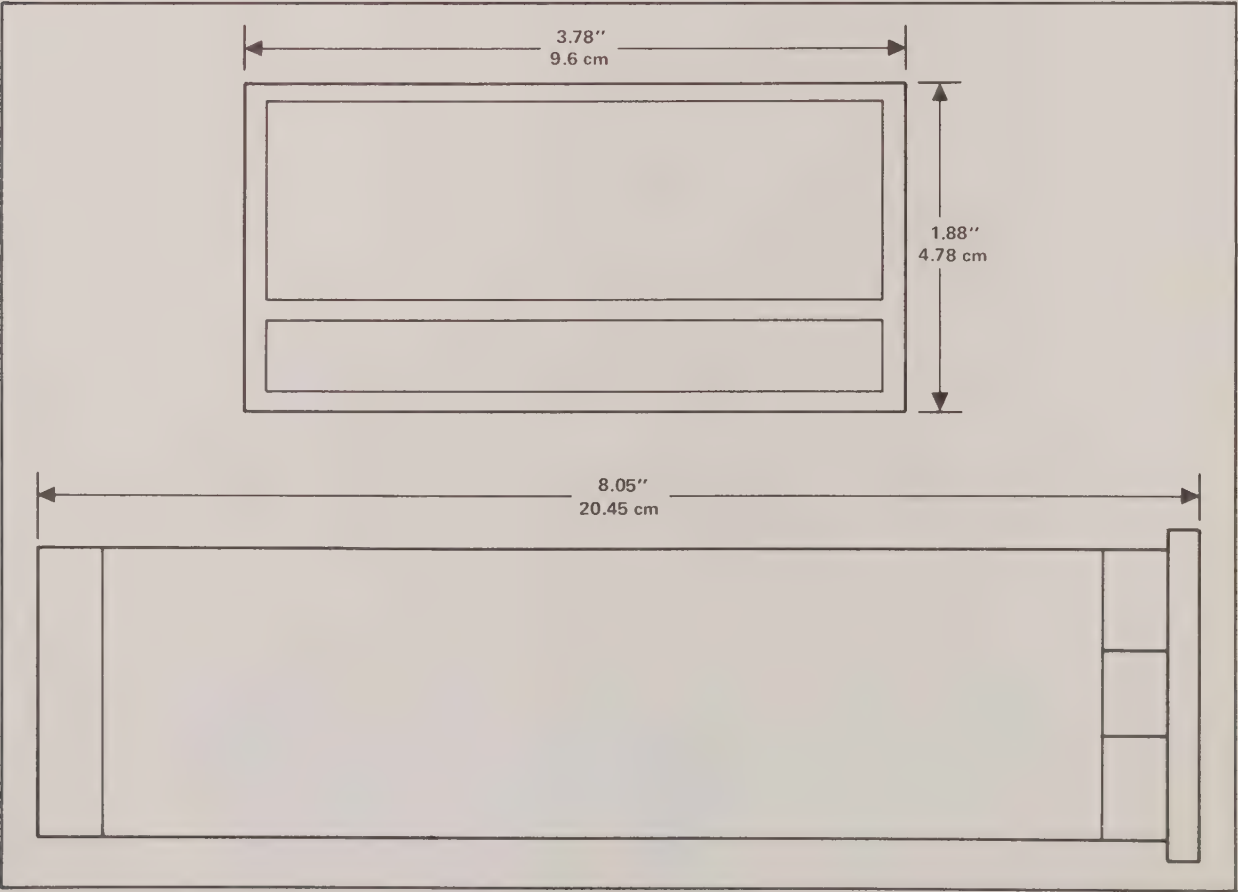


Figure 1-1. 2170A OUTLINE DRAWING



static awareness



A Message From
John Fluke Mfg. Co., Inc.



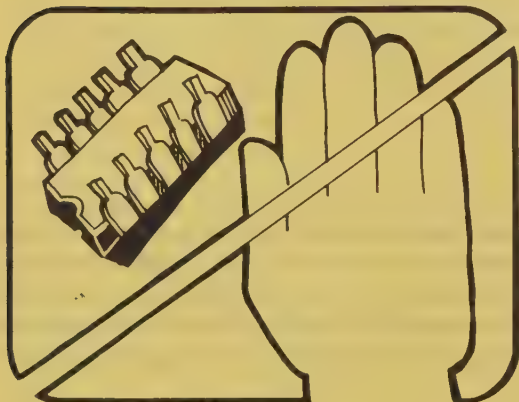
Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol



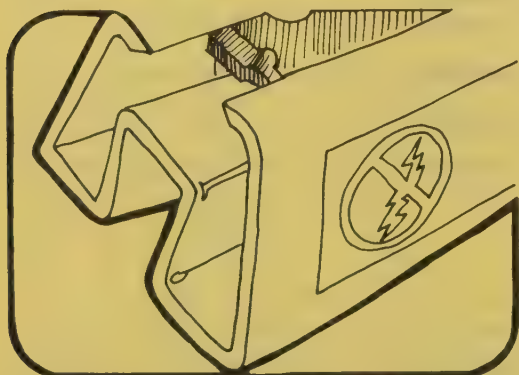
The following practices should be followed to minimize damage to S.S. devices.



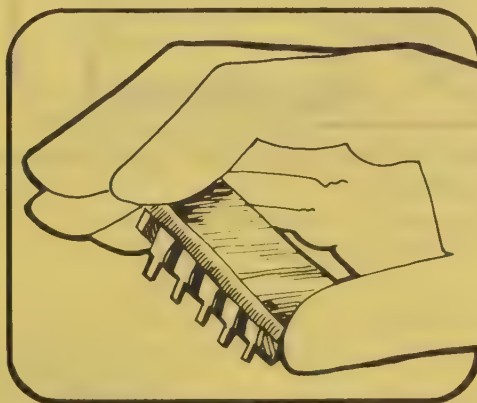
1. MINIMIZE HANDLING



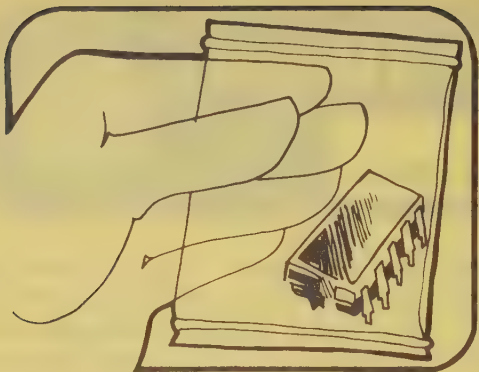
3. DISCHARGE PERSONAL STATIC
BEFORE HANDLING DEVICES



2. KEEP PARTS IN ORIGINAL CONTAINERS
UNTIL READY FOR USE.



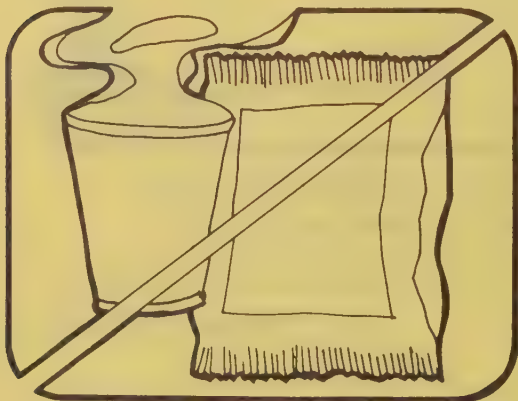
4. HANDLE S.S. DEVICES BY THE BODY



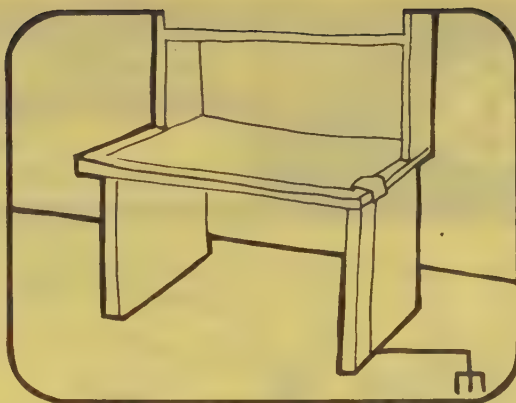
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
9. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
10. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Bag Size
453522	6" x 8"
453530	8" x 12"
453548	16" x 24"
454025	12" x 15"

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Section 2

Operating Instructions

WARNING!

Due to the possible presence of lethal voltages, the procedures in paragraphs 2-17, 2-21 and 2-23 should be performed by qualified personnel only.

2-1. INTRODUCTION

2-2. This section of the manual contains information regarding installation and operation of the Model 2170A Digital Thermometer. It is recommended that the contents of this section be read and understood before any attempt is made to operate the instrument. Should any difficulties arise during operation, please contact your nearest Fluke Technical Service Center, or the John Fluke Mfg. Co., Inc. P.O. Box 43210, Mountlake Terrace, WA 98043, Tel (206) 774-2211. A list of Technical Service Centers is located in Section 7 of this manual.

2-3. SHIPPING INFORMATION

2-4. The 2170A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, a thorough inspection should be made to reveal any possible shipping damage. Special instructions for inspection and claims are included in the shipping carton.

2-5. If reshipment of the instrument is necessary, the original container should be used. If the original container is not available, a new one can be obtained from the John Fluke Mfg. Co., Inc. Please reference the instrument model number when requesting a new shipping container.

2-6. INPUT POWER

2-7. The 2170A is factory wired to operate from one of three ac line voltages. These are: 100V ac, 50 to 440 Hz; 115V ac, 50 to 440 Hz; and 230V ac, 50 to 440 Hz. Before connecting the 2170A to the ac line, check to ensure that the instrument is wired to accommodate the local line voltage. A decal on the rear of the unit defines the particular line voltage required to operate the instrument.

2-8. The rear panel ac input connector is a three-prong, U-ground connector which permits the instrument to be connected, via the power cord, to the appropriate line voltage. The offset prong on this connector is connected to the 2170A power supply, and should be connected through the power cord to a high quality earth ground.

2-9. PANEL INSTALLATION

2-10. The 2170A is designed for installation in a console panel. The panel-mounting feature is an integral part of the instrument and does not require the use of a panel mounting kit. The unit conforms to DIN standards and will accommodate a panel thickness ranging from one-sixteenth of an inch to one-quarter of an inch. Use the following procedure to panel-mount the 2170A:

- a. Locate the mounting position on the panel and cut a 1.772 inch-by-3.622 inch (4.5 cm x 9.2 cm) rectangular hole.
- b. Remove the red, plastic display cover from the 2170A. Lift the cover at the bottom-center with a screw driver and continue to bow the cover until it pops out.
- c. Locate the two screws on either side of the bezel and turn them ccw until their cam nuts are their rear-most position.
- d. Slide the power cord and thermocouple (if attached) through the front-side of the prepared panel hole.
- e. Slide the 2170A into the panel hole (back-side first) until its bezel is flush with the panel. Make sure the cam nuts are inside their recesses during this procedure.

- f. Hold the 2170A firmly against the panel, and turn both side panel screws cw until they are snug. Do not apply excessive pressure. If the procedure was executed properly, the cam nuts should be extended behind the panel and the instrument should be firmly held in place.
- g. Place one side of the plastic display cover into position on the 2170A (frosted side out) and, bowing the

cover away from the instrument, snap the other side into position.

2-11. OPERATING FEATURES

2-12. The location of all 2170A controls, indicators and connectors are shown in Figure 2-1, and described in Table 2-1.

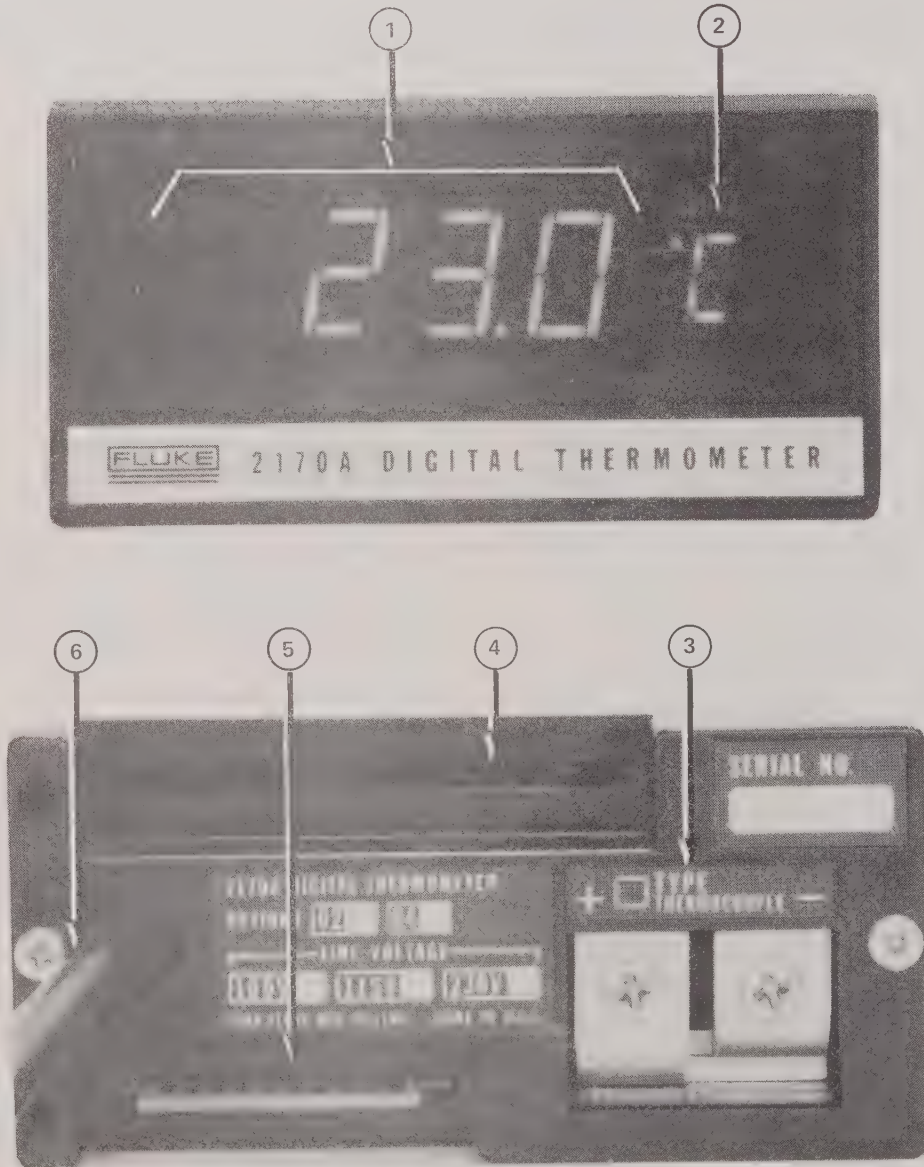


Figure 2-1. 2170A CONTROLS, INDICATORS AND CONNECTORS

Table 2-1. 2170A CONTROLS, INDICATORS AND CONNECTORS

REF. NO.	NAME	FUNCTION
1	Digital Display	Displays a four digit readout of the measured input temperature. Leading-zero suppression and a fixed decimal point are included. A minus sign is displayed for negative temperature measurements. The absence of a polarity sign indicates a positive temperature measurement.
2	Temperature Scale Indicator	Displays the temperature scale represented by the digital display data; °C or °F.
3	Thermocouple Input Connections	Provides screw-type terminals for connecting the thermocouple to the thermometer.
4	AOU/DOU I/O Port	Provides external access to the card-edge connector of the Digital Output Unit (Option -02) or the Analog Output Unit (Option -04), when installed.
5	Digital Comparator Connector	Provides the card-edge connections necessary to interface the 2170A with one or more 2162A Digital Comparators. See Section 6 of this manual for details concerning the 2162A.
6	Input Power Cable	Provides the means of connecting the instrument to ac line power.

2-13. OPERATING NOTES

2-14. The following paragraphs describe various conditions which should be considered before operating the 2170A.

2-15. Option Information

2-16. Supplementary operating instructions are necessary when operating a 2170A which is equipped with one of the available options. Detailed information regarding the operation of each available option is given in Section 6 of this manual, Option and Accessory Information.

2-17. Fuse Replacement

2-18. The ac line-input section of the 2170A power supply is fuse protected. The fuse is located on the interior of the unit near the power transformer. To access the fuse, disconnect the 2170A from line power, remove the rear-panel retaining screws located on both sides of the rear panel, and pull the pcb out the rear of the chassis. When replacement is necessary, use a MDL (Slo-blo) 1/16 A fuse.

2-19. Overload and Open Thermocouple Indication

2-20. The front panel display, in addition to providing a measurement reading, is designed to serve as an overrange or open thermocouple indicator. When the measurement range of the input thermocouple is exceeded, or when the thermocouple inputs are open circuited, the display will blink. The blinking indication does not mean that the instrument is being exposed to a damaging input condition.

2-21. Temperature Scale, °C or °F

2-22. The 2170A temperature scale can be selected from the front panel for direct readings in °C or °F. The desired scale is selected by positioning a jumper located behind the red-plastic display cover. Use the following procedure to change temperature scales:

NOTE

When the 2170A is energized the selected temperature scale is displayed at the right of the read-out.

- Remove line power from the instrument.
- Remove the red-plastic display cover from the 2170A. Lift the cover at the bottom center with a screw driver and continue to bow the cover until it pops out.
- Locate the °C/°F jumper on the Display PCB as shown in Figure 2-2.

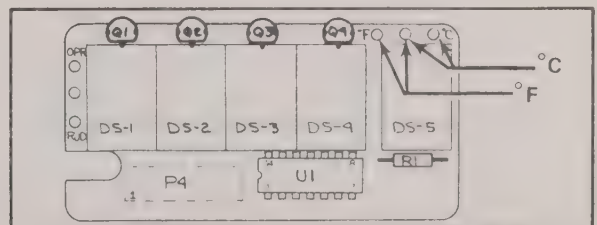


Figure 2-2. TEMP. SCALE (°C/°F) JUMPER LOCATION

- d. Remove the jumper using a pair of long nose pliers, and install it in the desired °C or °F position.
- e. Place one side of the plastic display cover into position on the 2170A (frosted side out) and, bowing the cover away from the instrument, snap the other side into position.
- e. Energize the 2170A. The selected temperature scale should be displayed.

2-23. Thermocouple Compatibility

2-24. The 2170A is designed to operate in conjunction with a selected type of thermocouple probe. A decal on the rear of the unit identifies the compatible thermocouple type. When necessary, the 2170A can be modified in the field to accommodate any one of the following thermocouple types: J, K, T or E. Use the following procedure to change thermocouple type:

- a. Refer to Table 1-1 in Section 1 of this manual and order the type select pcb which corresponds to the desired thermocouple type. These pcb's are low cost items and can be purchased from any of the John Fluke Technical Service Centers (See Section 7) or from the John Fluke Mfg. Co., Inc.
- b. Disconnect the 2170A from line power.
- c. Remove any ribbon-cable connectors that may be attached to the rear of the 2170A.
- d. Remove the screws on both sides of the rear panel, and slide the panel away from the unit.
- e. Grasp the thermocouple input connectors and carefully pull the pcb (s) out of the chassis.
- f. Unplug and remove the currently installed type select pcb from the position shown in Figure 2-3, and install the new one in its place.

NOTE

The thermocouple type is etched on the type select pcb's. When properly installed the arrows on the pcb point toward the digital display.

- g. Install the 2170A pcb in its chassis and secure the rear panel using the two side-center screws.
- h. Connect the new type thermocouple to the thermocouple input terminals.
- i. Place a piece of tape over the rear panel thermocouple type decal, and inscribe the new thermocouple type on it.

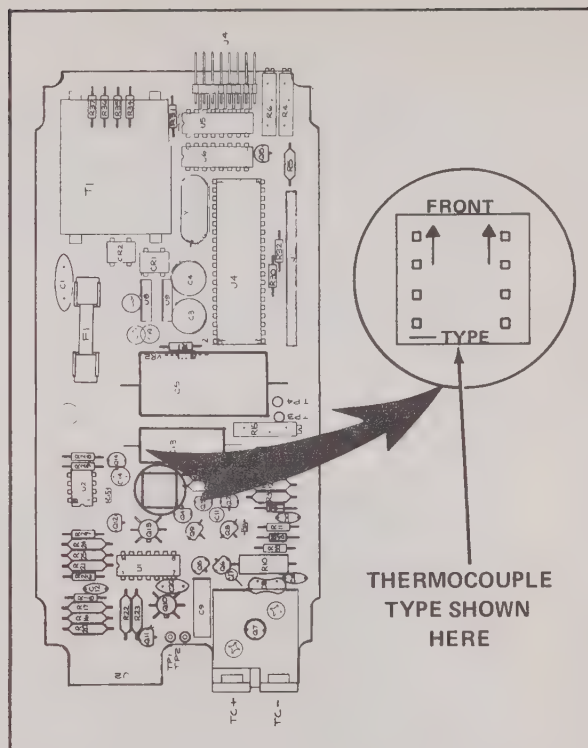


Figure 2-3. TYPE SELECT PCB, LOCATION AND INSTALLATION DETAILS

- j. Connect the unit to line power, and complete the routine calibration procedure given in Section 4 (Maintenance) of this manual.

2-25. OPERATION

- 2-26. With reference to previous paragraphs in this section, operate the 2170A as follows:
 - a. Refer to the rear-panel decal and connect a compatible thermocouple probe to the thermocouple input terminals. Observe polarity shown on decal.
 - b. Select the desired temperature scale (°C or °F) using the procedure given earlier.
 - c. Energize the instrument by connecting the power cord to the appropriate ac line power as defined on the rear-panel decal.
 - d. Refer to Section 6 of this manual for instructions concerning the -02 and -04 options.
 - e. Expose the thermocouple probe to a temperature within its specified range (see Specifications in Section 1). The probe temperature will be displayed on the front panel.

Section 3

Theory of Operation

3-1. INTRODUCTION

3-2. This section of the manual contains an overall functional description followed by a circuit analysis of the 2170A. Simplified circuit diagrams and timing diagrams are included, as necessary, to supplement the text. Detailed schematics are given in Section 8 of this manual.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. The Model 2170A Digital Thermometer, as shown in Figure 3-1, is a four-digit thermocouple thermometer capable of resolving 0.2°C or 0.2°F over a temperature range of -99.8 to $+999.8^{\circ}\text{C}$ or -99.8 to $+999.8^{\circ}\text{F}$. It features a reference junction compensator (to eliminate the need for an ice-bath reference junction), dual-slope integration, LSI digital control logic (includes linearization programs for J, K, E and T type thermocouples), and a four-digit LED display.

3-5. In operation, the 2170A executes a continuous series of measurement cycles to update the temperature display. The measurement cycle is controlled entirely by an LSI digital IC, and includes three major subcycles; Auto-Zero period, Integrate period and Read period. Each sub-cycle controls the operation of the analog section of a dual-slope integrator which, in turn, generates a compare output to control the digital conversion performed by the LSI digital IC.

3-6. The configuration of the analog section of the 2170A, during each phase of the measurement cycle, is established by a combination of FET switches that are controlled by the LSI digital IC. The measurement cycle begins with the Auto-Zero period. During this period, the reference junction compensation voltage and the accumulated dc offset voltages present in the analog section are sampled and held by capacitors. These voltages are used later in the measurement cycle to cancel measurement errors introduced by offset voltages and reference junction voltage errors created at the input

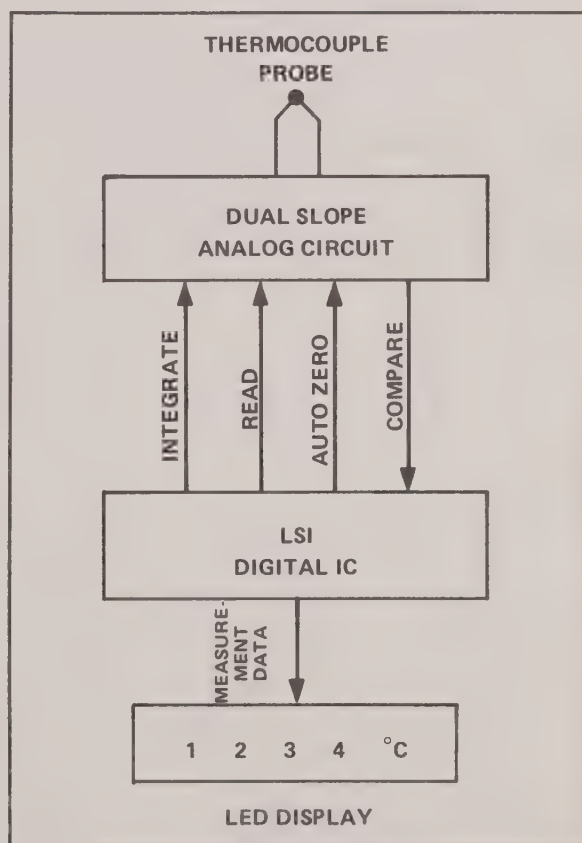


Figure 3-1. 2170A SIMPLIFIED BLOCK DIAGRAM

terminal connections. As a result, the final measurement is proportional to the thermocouple probe output voltage and does not include offset errors or reference junction voltage errors. During the Integrate period, the thermocouple input voltages (probe voltage and input terminal voltages) are applied to the integrator, and the algebraic sum of these voltages is integrated over a 100 ms period. At the end of this period, the thermocouple input voltages are removed from

the integrator and the Read period is started. A reference voltage is applied to the integrator during the Read period causing the integrator capacitor to be discharged at a linear rate. When the integrator output reaches zero, a compare signal is generated to end the Read period. The duration of the Read period is translated by the LSI digital IC to provide a digital indication proportional to the thermocouple probe temperature.

3-7. CIRCUIT ANALYSIS

3-8. Circuit analysis of the 2170A is discussed in two sections; digital and analog. The digital section is covered first, and particular attention is paid to the control it exercises on the analog section. The analysis of the analog section covers the analog measurement circuitry and the 2170A power supply.

3-9. Digital Section

3-10. The digital section of the 2170A consists of an LSI digital IC, a hex buffer, a seven-segment decoder/driver and an LED display. Its function is to convert the non-linear thermocouple probe voltage, as measured by the analog section, into a linear digital display. The display provides a direct reading of probe temperature in °C or °F.

3-11. The LSI digital IC contains all of the 2170A control logic and linearizing capability, and provides the hex buffer and seven-segment decoder with the data necessary to update the LED display. The linearization of the nonlinear input signal is accomplished by selecting one of eight programs which vary the rate at which the measurement counts are accumulated. The program is selected to match a particular thermocouple type. Program selection is accomplished by a series of plug-in type select pcb's which are available as accessories.

3-12. Measurement data is continuously strobed out of the LSI digital IC in bcd, character-serial format. At the end of each measurement cycle, an update flag is raised to signify that a new reading is available. When an overload occurs, the number of accumulated counts are stored and presented, along with a blanking pulse, as output data. The blanking pulse alternately turns the display on and off to indicate the presence of an overload.

3-13. The basic measurement cycle, as shown in Figure 3-2, comprises three subcycles; a 100 ms minimum Auto-Zero period, a 100 ms Integrate period, and a variable Read period. The auto-zero period is extended to 300 ms when an overload occurs. To accommodate settling times in the analog section, a 500 μ s hold signal is inserted at the beginning and at the end of the Integrate period.

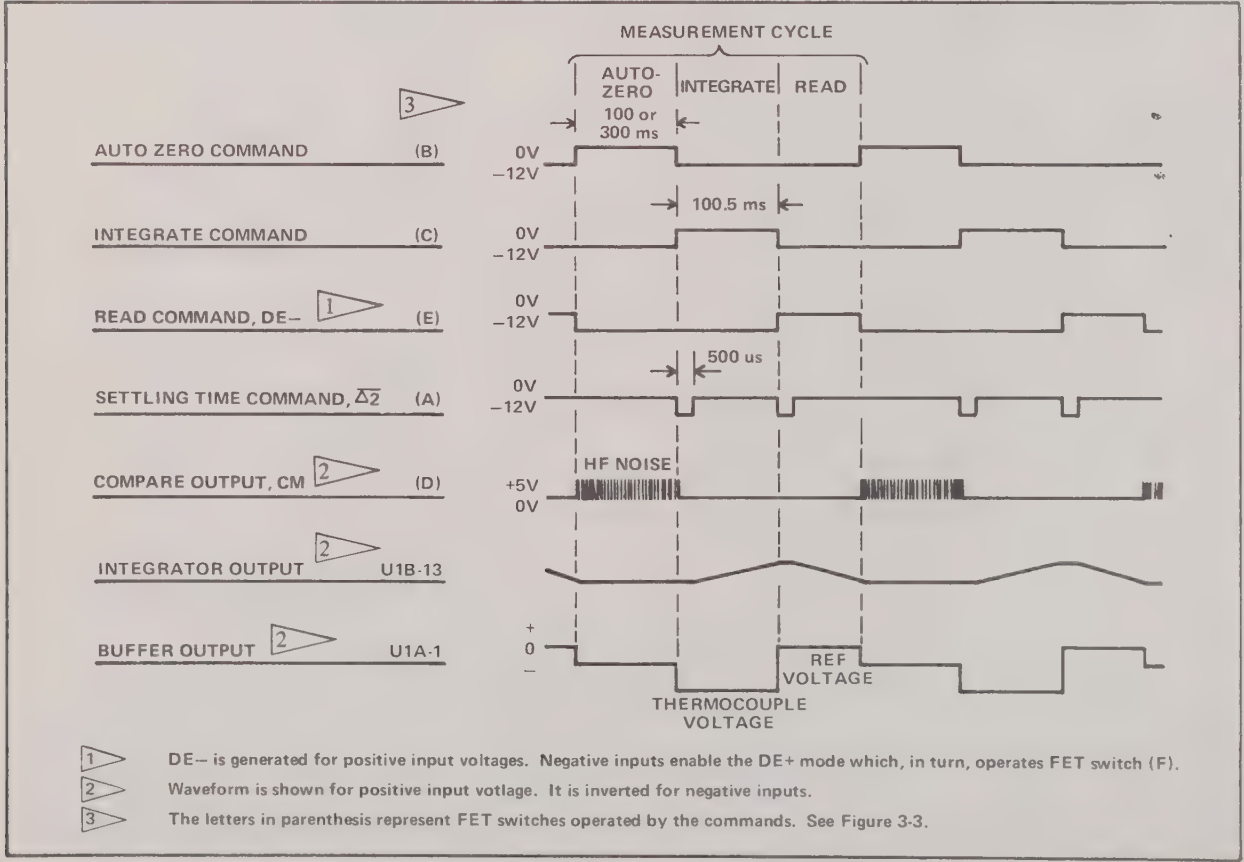


Figure 3-2. MEASUREMENT CYCLE WAVEFORMS

3-14. Analog Section

3-15. ANALOG MEASUREMENT CIRCUIT

3-16. The analog measurement circuit is shown in simplified form in Figure 3-3. It consists of a thermocouple input circuit, a reference-junction compensator, a voltage reference, a Buffer Amplifier, an Integrator, a Comparator, and a combination of FET switches. The switches are shown in their open state and are closed by the measurement cycle commands generated by the LSI digital IC. Each switch is assigned a letter designation which corresponds to a measurement cycle command shown in Figure 3-2.

3-17. The Thermocouple Input circuit consists of an R-C filter and a pair of voltage protection diodes. The difference between the thermocouple probe voltage and the input terminal voltage is passed through the filter and appears at the arm of switch C.

3-18. The Reference-Junction Compensator consists of an isothermal block, a pair of screw type input terminals, and a transistor temperature sensor. The isothermal block maintains a known temperature differential between the input terminals and the temperature sensing transistor. Thermocouple voltages introduced by the dissimilar metals at the input terminals vary as the isothermal block adjusts to ambient temperature.

erature. Temperature changes are sensed by the forward-biased transistor which produces a correction voltage equivalent to the thermocouple voltage created at the input terminals. Predictable characteristics of a forward-biased P-N junction allow the Reference-Junction Compensator to function over a wide temperature range. The correction voltage is matched to the thermocouple probe type by a selected Offset Resistor which is supplied on a plug-in type select pcb. The correction voltage appears at the arm of switch B1.

3-19. The voltage reference consists of a resistor divider which is supplied by an accurate 6.4V dc reference voltage. The divider is calibrated to match the thermocouple probe type by a selected resistor on the plug-in type select pcb. Two voltages are available at the divider outputs; $0.5 \times V_{ref}$ and $1.5 \times V_{ref}$. These voltages appear at the arms of switches B2 and E, respectively.

3-20. The Buffer, Integrator and Comparator amplifiers combine to perform the analog functions of the Integrate, Read and Auto-Zero periods. The Buffer is used to provide integrator inputs during all three periods. The Integrator integrates the Buffer output voltage during the Integrate and Read periods, and functions, in combination with the Comparator, as a closed-loop amplifier during the Auto-Zero period.

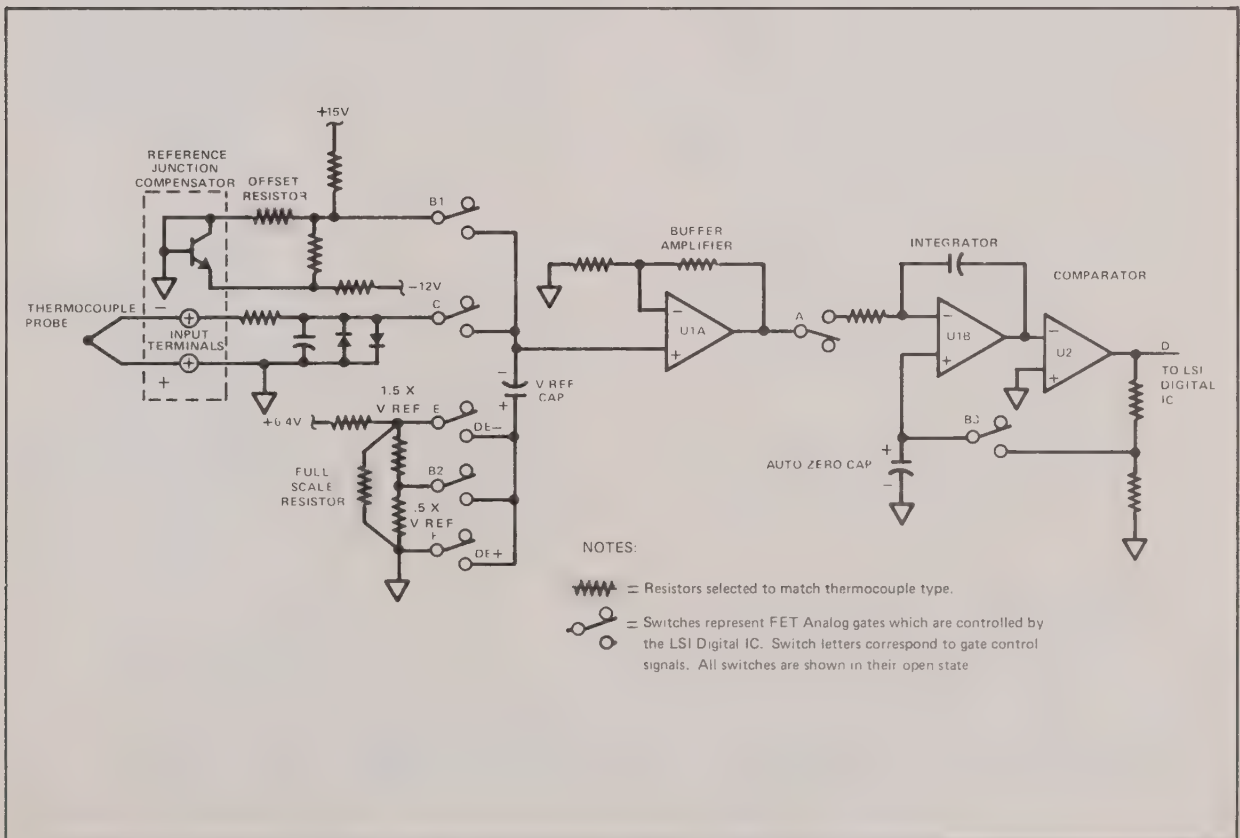


Figure 3-3. ANALOG SECTION, SIMPLIFIED CIRCUIT DIAGRAM

3-21. During the first phase of each measurement cycle, the analog section goes through an Auto-Zero period. During this time, three auto-zero switches (B1, B2 and B3) are closed by the Auto Zero command from the LSI digital IC. Two of the switches (B1 and B2) charge the V ref capacitor to a level equal to the algebraic sum of the $0.5 \times V_{\text{ref}}$ output, plus the correction voltage generated by the Reference-Junction Compensator. At the same time, the correction voltage is amplified by the Buffer Amplifier and presented through switch A to the Integrator input. The third switch (B3) connects the Integrator and Comparator in a closed loop configuration and allows the Auto-Zero capacitor to charge to a value which is proportional to the Reference-Junction-Compensator correction voltage plus the offset voltages present in the Buffer, Integrator and Comparator amplifiers. At the end of the measurement cycle switches B1, B2 and B3 are opened. The V ref capacitor and the Auto-Zero capacitor retain their charge for use later in the measurement cycle.

3-22. The Integrate period starts on the leading edge of the Integrate Command from the LSI digital IC; switch A is open and switch C is closed. The thermocouple input voltage is applied through switch C to the Buffer input. After a 500 μs settling period, switch A closes and the Buffer output voltage is applied to the Integrator input for 100 ms. As the integrator capacitor charges, the Integrator drives the Comparator output to either 0 or +5V dc to indicate the polarity of the thermocouple input voltage, positive or negative, respectively. The comparator output is sent to the LSI digital IC for use during the Read period. At the end of the Integrate period, the integrator capacitor is charged to a level and polarity that is proportional to the thermocouple probe voltage and switch C returns to its open state.

3-23. The Read period starts at the end of the Integrate period and one-of-two Read Modes is enabled depending upon the input polarity sensed by the comparator during the Integrate period. If a positive input is sensed, a DE– Read Mode is enabled. Similarly a DE+ Read Mode is enabled when a negative input is sensed.

3-24. If the DE– Read Mode is commanded, switch A is opened and E is closed. Switch E applies a $1.5 \times V_{\text{ref}}$ input to the positive side of the V ref capacitor. This voltage is

algebraically added to the voltage stored in the V ref capacitor during the previous Auto-Zero period ($0.5 \times V_{\text{ref}}$ + Reference-Junction-Compensator voltage). As a result, the input to the Buffer Amplifier is a positive voltage equal to V ref plus the Reference Junction-Compensator voltage.

3-25. If the DE+ Read Mode is commanded, switch A is opened and F is closed. Switch F grounds the positive side of the V ref capacitor and causes the Buffer amplifier input to be driven to the voltage stored in the V ref capacitor during the previous Auto-Zero period ($0.5 \times V_{\text{ref}}$ + Reference-Junction Compensator voltage). As a result, the input to the Buffer Amplifier is a negative voltage equal to $0.5 \times V_{\text{ref}}$ plus the Reference-Junction-Compensator voltage.

3-26. After a 500 μs settling time, switch A closes and the Buffer output voltage is applied to the Integrator input. This causes the integrator capacitor to discharge at a linear rate determined by the reference voltage. The discharge continues until the integrator output voltage reaches zero volts, the level existing prior to the integrate period. This level is sensed by the Comparator which signals the LSI digital IC to terminate the A/D conversion of measurement data.

3-27. Offset voltages present during the Integrate and Read periods are cancelled out by offset voltages that were sampled and held during the Auto-Zero period. However, the Reference-Junction-Compensator voltage (also sampled and held during Auto Zero) is added to the integrator voltage during the Integrate period. As a result, the displayed temperature is equal to the thermocouple probe temperature.

3-28. POWER SUPPLY

3-29. The 2170A power supply consists of a power transformer, fuse, power input cord, and regulating circuitry. The function of the power supply is to provide +5, +6.8, +15 and –12V dc operating voltages for the 2170A circuitry. In addition a +5V ac output is available for use by ground-isolated output options. The +6.8, +15 and –12V dc supplies are regulated, and the +5V dc supply is unregulated. All operating voltages are generated using conventional regulating and/or isolating techniques. Refer to the detailed schematic in Section 8 of this manual.

Section 4

Maintenance

WARNING!

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual provides information about warranty, factory service, maintenance, performance testing, routine recalibration and recalibration after repair. The performance test is recommended when the instrument is received and later as a preventive maintenance tool or for testing after repair. The test verifies performance at several temperatures within the range of a given thermocouple type. Specifications are provided both for annual and for a more precise 90-day performance-testing cycle.

4-3. SERVICE INFORMATION

4-4. The instrument is warranted for a period of one year upon delivery to the original purchaser. The WARRANTY is located on the back of the title page located in the front of this manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world-wide locations. A complete list of these service centers is included in Section 7 of this manual. If requested, an estimate will be provided to the customer before any work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

4-7. Access Information

4-8. Removal of the instrument from its case is necessary only for maintenance. Routine calibration can be done without such removal.

- a. Calibration access can be obtained by removing the red-plastic display lens on the front panel. Lift

the bottom-center of the lens with a small screw driver until the lens pops out of position. The lens is replaced by placing one side into position and then bowing the lens away from the front panel until the other side can be pushed into position. When the lens is released, it secures itself in position.

- b. Maintenance access to the display and main pcb assemblies is achieved by removing the rear-panel retaining screws located on each side of the rear panel, and then pulling the main pcb assembly and mylar insulation sheet from the rear of the case. Line power should be disconnected from the thermometer when removing or installing pcb's.

4-9. Cleaning

- 4-10. Clean the instrument periodically to remove dust, grease and other contamination. Use the following procedure:

CAUTION!

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They will react with plastic materials used in manufacture of the instrument.

- a. Clean the front panel and case with a soft cloth dampened with a mild solution of detergent and water.
- b. Clean the surface of the pcb using clean dry air at low pressure (≤ 20 psi). If grease is encountered,

spray with Freon T. F. Degreaser or anhydrous alcohol and remove grime with clean dry air at low pressure.

4-11. Fuse Replacement

WARNING!

DISCONNECT THE UNIT FROM LINE POWER BEFORE ATTEMPTING FUSE REPLACEMENT.

4-12. The input power fuse is located on the interior of the unit near the power transformer. If replacement is necessary, use an MDL (Slo-blo) 1/16A fuse.

4-13. Service Tools

4-14. No special tools are required for maintenance or repair.

4-15. PERFORMANCE TEST

4-16. Table 4-1 lists the equipment required for performance testing and recalibration. If the recommended model of test equipment is not available, a substitute that meets the minimum use specifications may be used. Table 4-2 outlines the Performance Test. A Performance Checklist at the end of this section may be reproduced or removed to provide a written record of results. The Performance Test verifies instrument performance to specifications for initial acceptance or for maintenance. (Periodic recalibration requires the calibration procedure beginning in paragraph 4-27). If the thermometer fails to meet specifications, it requires recalibration or repair. Review Table 4-2, then continue.

NOTE

The Performance Test should be conducted at an ambient temperature of $25 \pm 2.0^{\circ}\text{C}$ ($77.0 \pm 3.6^{\circ}\text{F}$).

4-17. Set-up Procedure

4-18. The following steps prepare for performance testing:

- Remove the thermometer from its case.
- Locate the RJD jumper on the display pcb (See Figure 4-1) and set it to the RJD position. (This defeats the reference-junction circuitry.)
- Connect a voltage divider to a dc voltage calibrator as in Figure 4-2. (See Table 4-1 for specifications.)
- Connect the voltage-divider output to the thermometer input terminals. Match polarity.

Table 4-1. TEST EQUIPMENT REQUIREMENTS

TEST EQUIPMENT	MINIMUM USE SPECIFICATIONS	RECOMMENDED MODEL
Thermocouple Probes	Type J, K, T, E, R, S, C ANSI C96.1 (select type compatible with thermometer)	Omega TJ36 Series, Grounded Sheath
Mercury, thermometer (either C or °F)	0.02°C Resolution 0.05°F Resolution	Princo Model ASTM-56C Princo Model ASTM-56F
Dewar Flask/Cap	1-pint capacity	Thermos
DC Voltage Calibrator	Output Voltage: 0 to 10V Accuracy: 0.002% Resolution: 10 mV	Fluke Model 343A
Voltage Divider 100:1 or Kelvin-Varley Divider (Shunt output with 1 µf capacitor)	Ratio: 0.005%	Fluke A21-5 or Fluke 720A or Fluke 750A
Variable Line-Voltage Transformer	100, 115, 230V ac, as required, $\pm 10\%$	General Radio VARIAC W5HM
Decade Resistor	Accuracy: 1% Ranges: 1K, 10K and 100K	General Radio 1434

Table 4-2. PERFORMANCE TEST DESCRIPTION

TEST	PERFORMANCE SPECIFICATIONS	TEST METHOD	PARAGRAPH NO.
Setup	— — — —	— — — —	4-17
Overload and Open Input Test	The display flashes to indicate both over range input voltages and open input terminals.	An over range voltage is applied to the thermocouple input terminals, and the input terminals are open circuited.	4-19
Line Voltage Regulation	Satisfactory performance with any line voltage within $\pm 10\%$ of nominal; 100, 115 or 230V ac.	The display is monitored during the accuracy test as the line voltage is varied.	4-21
Accuracy Test	Temperature Accuracy as stated in Table 4-3	Known input voltages are substituted for the thermocouple inputs. Cardinal-point checks ensure accuracy over the entire temperature range.	4-23
Internal Temperature Rise	$<5.0^{\circ}\text{C}$ (9.0°F) above ambient	The thermocouple input terminals are shorted and the temperature of the reference junction is displayed.	4-25

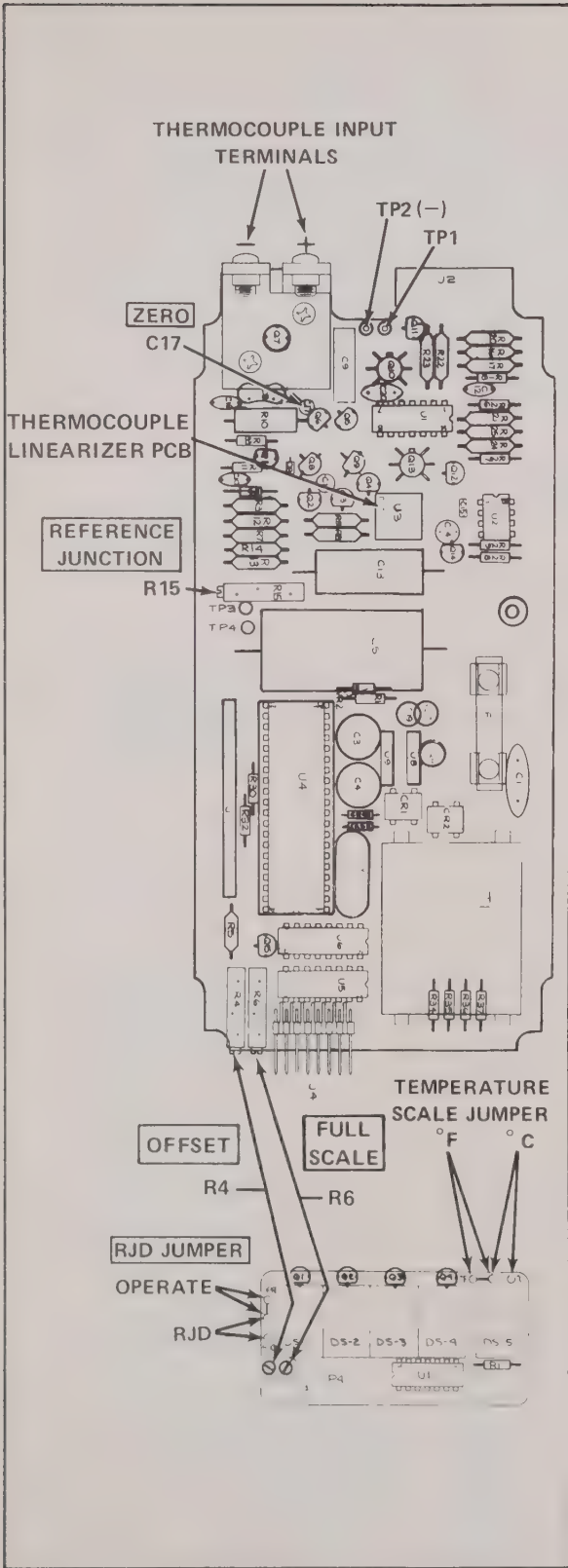


Figure 4-1. TEST POINT AND ADJUSTMENT LOCATIONS

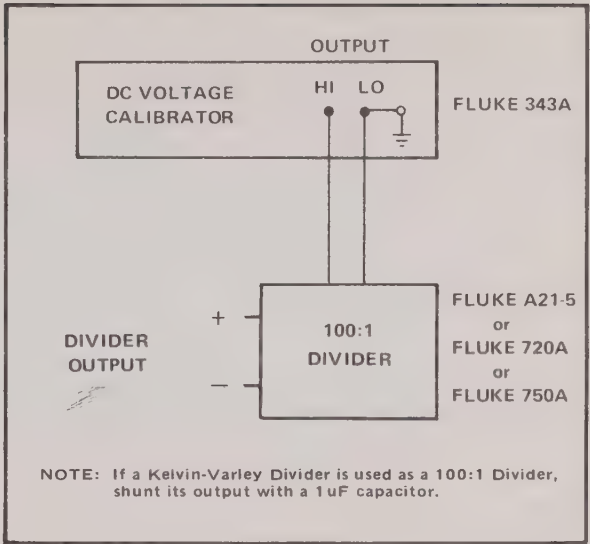


Figure 4-2. VOLTAGE DIVIDER—CALIBRATOR CONNECTION

- e. Connect a variable line-power transformer to line power and adjust the output to the nominal line voltage at which the thermometer is designed to operate; 100, 115, or 230V ac.
- f. Connect a power cord between the transformer output and the thermometer ac line connector.
- g. Set the TEMP-scale jumper to °F or °C. (See Figure 4-1.)
- h. Set the calibrator to zero volts output, 10 volt range, and turn it on.

4-19. Overload and Open Input

- 4-20. The following procedure tests the thermometer overload and open-circuit detectors:
- a. Set the calibrator output to 10V dc. The thermometer display should begin to flash. While the display is lit, it should read the high end of the temperature range assigned to the compatible thermocouple type:

J	=	999.8° F	or	777.8° C
K	=	999.8° F	or	999.8° C
T	=	752.0° F	or	400.0° C
E	=	999.8° F	or	999.8° C
 - b. Set the calibrator output to 0V dc.
 - c. Remove the input connections at the thermometer thermocouple input terminals. The display should

begin to flash and read the low end of the temperature range:

J	=	-99.8° F	or	-99.8° C
K	=	-99.8° F	or	-99.8° C
T	=	-99.8° F	or	-99.8° C
E	=	-99.8° F	or	-99.8° C

- d. This completes the Overload and Open-Input test.

4-21. Line Voltage Regulation

4-22. Line voltage regulation is tested in conjunction with the accuracy test given in the following paragraphs. As the accuracy test is executed, vary the line voltage $\pm 10\%$ with the variable line-power transformer to ensure the proper operation within the line-voltage limits.

4-23. Accuracy Test

4-24. The following procedure tests the accuracy of the thermometer:

- Connect the voltage-divider leads to the thermocouple input terminals. Match polarity.
- Refer to Table 4-3 and select the group of values that correspond to the thermocouple type used with the thermometer.

- Sequentially, set the calibrator to obtain each of the divider output voltages listed within the selected group, and check the thermometer display against the appropriate display limits; 90-day or 1-year. Vary the ac voltage over the specified $\pm 10\%$ operating range. Check to see that the thermometer is still reading within accuracy specifications.

- Remove the voltage divider from the thermometer input.

- Set the RJD jumper to the operate position.

- Install the thermometer, with mylar insulation sheet underneath, in its case.

- Connect a thermocouple of the appropriate type to the thermocouple input terminals. Match polarity. J, K, T and E thermocouples have a red wire for the negative lead.

- Place the thermocouple in a room-temperature lag-bath. (See Figure 4-3 for an illustration of lag-bath construction. Two holes should be drilled in the thermos lid to provide a snug fit for the mercury thermometer and thermocouple probe.)

Table 4-3. TEMPERATURE ACCURACY

TYPE	DIVIDER OUTPUT (mV dc)	°F		DIVIDER OUTPUT (mV dc)	°C	
		DISPLAY LIMITS			DISPLAY LIMITS	
		90 DAY	1 YEAR		90 DAY	1 YEAR
J	29.263	990.8 to 993.2	990.4 to 993.6	42.640	754.9 to 756.3	754.5 to 756.7
	2.288	110.8 to 113.2	110.4 to 113.6	2.288	43.7 to 45.1	43.3 to 45.5
	-1.643	-29.6 to -26.4	-30.1 to -25.9	-2.175	-45.4 to -43.4	-45.6 to -43.2
	-3.198	-89.6 to -86.4	-90.1 to -85.9	-3.686	-78.8 to -76.8	-79 to -76.6
K	22.059	990.6 to 993.4	990.2 to 993.8	40.404	976.7 to 978.9	976.4 to 979.2
	2.709	150.6 to 153.4	150.2 to 153.8	0.884	21.1 to 23.3	20.8 to 23.6
	-1.691	-50 to -46	-50.6 to -45.4	-1.691	-45.6 to -43.2	-45.9 to -42.9
	-2.475	-90 to -86	-90.6 to -85.4	-2.848	-79 to -76.6	-79.3 to -76.3
T	20.188	731 to 733	730.5 to 733.5	19.497	377.2 to 378.4	376.9 to 378.7
	0.879	71 to 73	70.5 to 73.5	0.879	21.6 to 22.8	21.3 to 23.1
	-1.240	-29.7 to -26.3	-30.9 to -25.1	-2.009	-56.6 to -54.6	-57.2 to -54
	-2.370	-89.7 to -86.3	-90.9 to -86.3	-2.720	-78.8 to -76.8	-79.4 to -76.2
E	39.694	990.7 to 993.3	990.2 to 993.8	74.694	976.8 to 978.8	976.4 to 979.2
	2.694	110.7 to 113.3	110.2 to 113.8	2.694	43.4 to 45.5	43 to 45.8
	-1.897	-29.7 to -26.3	-31 to -25	-3.080	-56.6 to -54.6	-57.3 to -53.9
	-3.641	-89.7 to -86.3	-91 to -85	-4.196	-78.8 to -76.8	-79.5 to -76.1

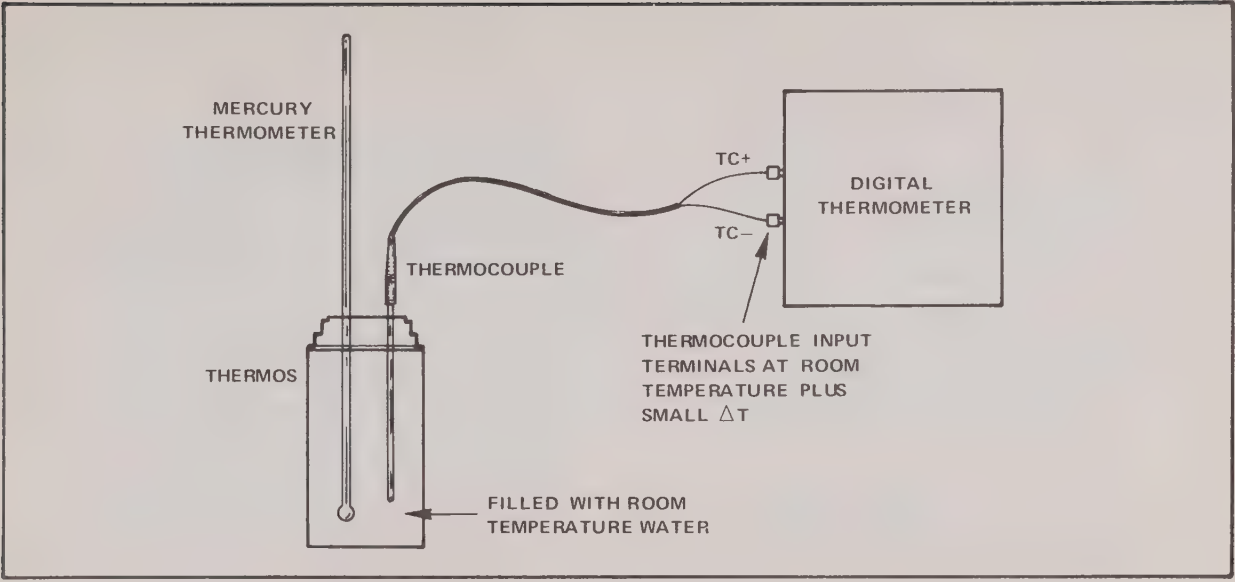


Figure 4-3. ROOM TEMPERATURE LAG BATH

- i. Refer to Table 4-4. Determine if the thermometer display is within the specified range of the lag-bath temperature reading.

NOTE

Allow sufficient time for the mercury thermometer to come to a stable lag-bath temperature reading.

Table 4-4. REFERENCE-JUNCTION ACCURACY LIMITS

TYPE THERMOCOUPLE	°F	°C
J	±1.5°	±1.5°
K	±2.0°	±1.5°
T	±1.5°	±1.5°
E	±1.5°	±1.5°
The thermometer should read within the above limits for either the 90-day or 1-year check.		

- j. This completes the accuracy test portion of the Performance Test.

4-25. Internal Temperature Rise

4-26. The following procedure measures the thermometer's internal temperature as sensed by the reference junction:

- a. Connect a copper wire between the thermocouple input terminals (in place of the thermocouple leads used in the preceding test).

NOTE

This procedure assumes that the thermometer has been energized for at least 30 minutes.

- b. Monitor the ambient temperature (room temperature) using a mercury thermometer near the back of the digital thermometer.
- c. The digital thermometer will display the temperature of the internal reference junction. This temperature should not exceed the ambient temperature by more than 5.0° C (9.0° F).
- d. Remove the short from the thermocouple input terminals.
- e. This completes the test for internal temperature rise.

4-27 CALIBRATION

4-28. The thermometer should be calibrated every year or every 90 days, depending on the desired accuracy. Calibration should be performed also after the thermometer has been repaired or after the thermocouple linearizer (type-select) pcb has been changed.

4-29. Calibration of either the °F or °C scale, ensures the accuracy of both scales. Either scale can be verified after calibration by executing the accuracy portion of the Performance Test.

4-30. Routine calibration or calibration after change of the thermocouple type can be made from the front of the instrument. Maintenance calibration or reference-junction adjustment requires removal of the instrument from its case. (See Paragraph 4-7.)

4-31. Calibration Procedure

4-32. SET-UP FOR CALIBRATION

- a. Complete the equipment connections shown in Figure 4-2, by doing the following:
 - 1. Connect the 100:1 divider specified in Table 4-1.
 - 2. Apply power to the calibrator and turn it on. Allow sufficient warm-up time to assure calibration-output-voltage accuracy.
- b. Remove the thermometer from its case only for maintenance calibration or reference-junction adjustment. (See Paragraph 4-7.)
- c. Locate the RJD jumper on the display pcb. Set it to the RJD position. (This defeats the reference-junction circuitry.)
- d. Connect the voltage-divider output to the thermocouple input terminals.
- e. Connect a short length of copper wire between the thermocouple input terminals.
- f. Set the TEMP-scale jumper to °F or °C.

4-33. ZERO ADJUSTMENT

- a. Adjust C17 to obtain a steady or flashing 0.0 or -0.0 for the Celsius scale, or to obtain a steady 32.0 for the Fahrenheit scale.

4-34. FULL SCALE ADJUSTMENT

- a. Determine the thermocouple compatible with the thermometer. The markings on the plug-in linearizer (type-select) pcb indicate the thermocouple type. (See Figure 4-1.) The instrument will have to be removed from its case to see the linearizer pcb. (See Paragraph 4-7.)
- b. Remove the short and connect the 100:1 divider output to the thermocouple input terminals. Match polarity.

- c. Refer to Table 4-5 and set the calibrator output to obtain the voltage divider output specified for the compatible thermocouple type, for the degree scale being used.

Table 4-5. FULL SCALE CALIBRATION

PROBE TYPE	°F		°C	
	DIVIDER OUTPUT (mV dc)	DISPLAY READING	DIVIDER OUTPUT (mV dc)	DISPLAY READING
J	+29.263	992.0°F	42.640	755.6°C
K	+22.059	992.0°F	40.404	977.8°C
T	+20.188	732.0°F	19.497	377.8°C
E	+39.694	992.0°F	74.694	977.8°C

- d. Adjust the FULL-SCALE CAL potentiometer, R6 (Figure 4-1), to obtain the temperature display specified in Table 4-5.

4-35. OFFSET ADJUSTMENT

- a. Set the RJD jumper to the operate position.
- b. Remove the divider leads from the thermocouple input terminals.
- c. Short the thermocouple input terminals with a small piece of copper wire.
- d. Remove the 100:1 divider from the calibrator output.
- e. Set the calibrator to the 10V dc range.
- f. Adjust the calibrator output to .5785V dc.

CAUTION!

- Be sure the voltage output of the calibrator is .5785V dc before proceeding to the next step. Improper voltage could damage the digital thermometer. Do not use the divider to obtain .5785V dc because the output impedance will create an error.
- g. Connect the positive lead from the calibrator to the positive thermocouple input terminal.
 - h. Connect the negative lead from the calibrator to Test Point 2. (TP2(-) in Figure 4-1).
 - i. Adjust the OFFSET CAL potentiometer, R4, for a temperature display of 25.0° C (77.0° F).
 - j. Remove the calibrator output from the plus input terminal and TP2(-).

- k. Remove the short at the thermocouple input terminals.
 - l. If the thermometer is being calibrated on a routine calibration cycle, or because of thermocouple type-change, this completes calibration. Reassemble the thermometer.
 - m. If the thermometer is being recalibrated because of repair or if reference-junction adjustment is desired, proceed with paragraph 4-36.
- 4-36. REFERENCE-JUNCTION ADJUSTMENT
- a. Connect a compatible thermocouple probe to the input terminals. Match polarity. J, K, T and E thermocouples have a red wire for the negative lead.
 - b. Place the thermocouple in a room-temperature lag bath. (See Figure 4-3 for an illustration of lag-bath construction.)
 - c. Use an accurate mercury thermometer to monitor the temperature of the lag-bath. (See Table 4-1.)
 - d. Adjust the REFERENCE-JUNCTION CAL potentiometer, R15, to obtain a display that agrees with the lag-bath temperature.
 - e. Remove the thermocouple and reassemble the digital thermometer.
- 4-37. REFERENCE-JUNCTION BIAS-RESISTOR SELECTION
- 4-38. If the reference-junction transistor Q7 is replaced, then the reference-junction bias resistor R14 must also be replaced. This is a selected resistor which must be matched to Q7. To select the resistor:
- a. Complete the calibration paragraphs 4-32 through 4-35.
 - b. Connect a compatible thermocouple probe to the input terminals. Match polarity. J, K, T and E thermocouples have a red wire for the negative lead.
 - c. Center the reference-junction pot R15.
 - d. Connect a decade resistance box that has ranges including 1K, 10K and 100K, in place of the reference-junction bias resistor R14. (See Table 4-1.)
 - e. Place the thermocouple in a room-temperature lag bath. (See Figure 4-3 for an illustration of lag-bath construction.)
 - f. Use an accurate mercury thermometer to monitor the temperature of the lag bath. (See Table 4-1.)
 - g. Adjust the decade resistance box for the value from Table 4-6 that causes the thermometer to read closest to lag-bath temperature. This will be the value of the reference-junction bias resistor R14.
 - h. Disconnect the decade box and install the selected R14.
 - i. Adjust the reference junction potentiometer so that the thermometer reading matches the lag-bath temperature.
 - j. Remove the thermocouple and reassemble the digital thermometer.
 - k. This completes the selection of R14. This also completes the calibration of the reference junction.

Table 4-6. BIAS RESISTOR VALUES

VALUE	JOHN FLUKE PART NUMBER	VALUE	JOHN FLUKE PART NUMBER
49.9K	268821	90.9K	223537
52.3K	237248	100K	248807
54.9K	271353	110K	234708
57.6K	289116	124K	288407
60.4K	291419	140K	289439
63.4K	235382	162K	375998
68.1K	236828	191K	375923
73.2K	237222	237K	288373
78.7K	289058	309K	235283
84.5K	229492	562K	235358

4-39. CALIBRATION TECHNIQUES

4-40. Calibration of the reference junction (R15) can be performed using any type of thermocouple. Once the reference junction has been calibrated for one type of thermocouple, it will be in calibration for use with any other thermocouple type. Therefore, a calibration facility that maintains several digital thermometers which are configured for different thermocouple types, requires only one thermocouple probe and its corresponding linearizer (type-select) pcb in order to calibrate the reference junction of all of the instruments. A K-type thermocouple and lin-

earizer pcb are recommended. The following procedure illustrates:

- a. Calibrate the repaired thermometer with the K-type thermocouple and K-type linearizer pcb installed. Follow paragraphs 4-32 through 4-36. This calibrates the reference junction.
- b. Change the thermometer to another type of thermocouple by changing the linearizer pcb and repeating paragraphs 4-32 through paragraph 4-35 only. These paragraphs do not require the actual thermocouple probe, but accomplish full-scale calibration for the non-K-type probe without disturbing the reference-junction calibration just set in a. above.

4-41. Thermocouple Accuracy Relating to the Reference-Junction Calibration Technique

4-42. The thermocouples specified in the list of calibration equipment meet specifications of ANSI Standard C96.1. The specifications for these probes can be as much

as 4°F absolute error at or near room temperature. The first conclusion is that those probes could produce a calibration error of $\pm 4^{\circ}\text{F}$ when used for calibrating the reference junction. This is an erroneous conclusion. Figure 4-3 illustrates the set-up for calibration. Figure 4-4A illustrates the reference-junction compensation circuitry and Figure 4-4B illustrates the equivalent thermocouple circuit formed by the connection of the thermocouple to the input of the instrument. Note that in Figure 4-4B, the two thermocouple junctions formed at the input of the instrument (plus thermocouple wire (+TC) to the plus input terminal and the minus thermocouple wire (-TC) to the minus input terminal) can be represented as a single junction of +TC to -TC whose temperature is that of the input terminals of the instrument. The reference-junction circuitry senses the terminal temperature and generates a voltage that is equal to the voltage generated by the equivalent thermocouple formed at the input terminals referenced to ice point (See Figure 4-4A). For example, suppose the input terminals of the instrument and the attached probe are at the same temperature of 25°C . Since the thermocouple output voltage is proportional to the temperature between the two junctions, the

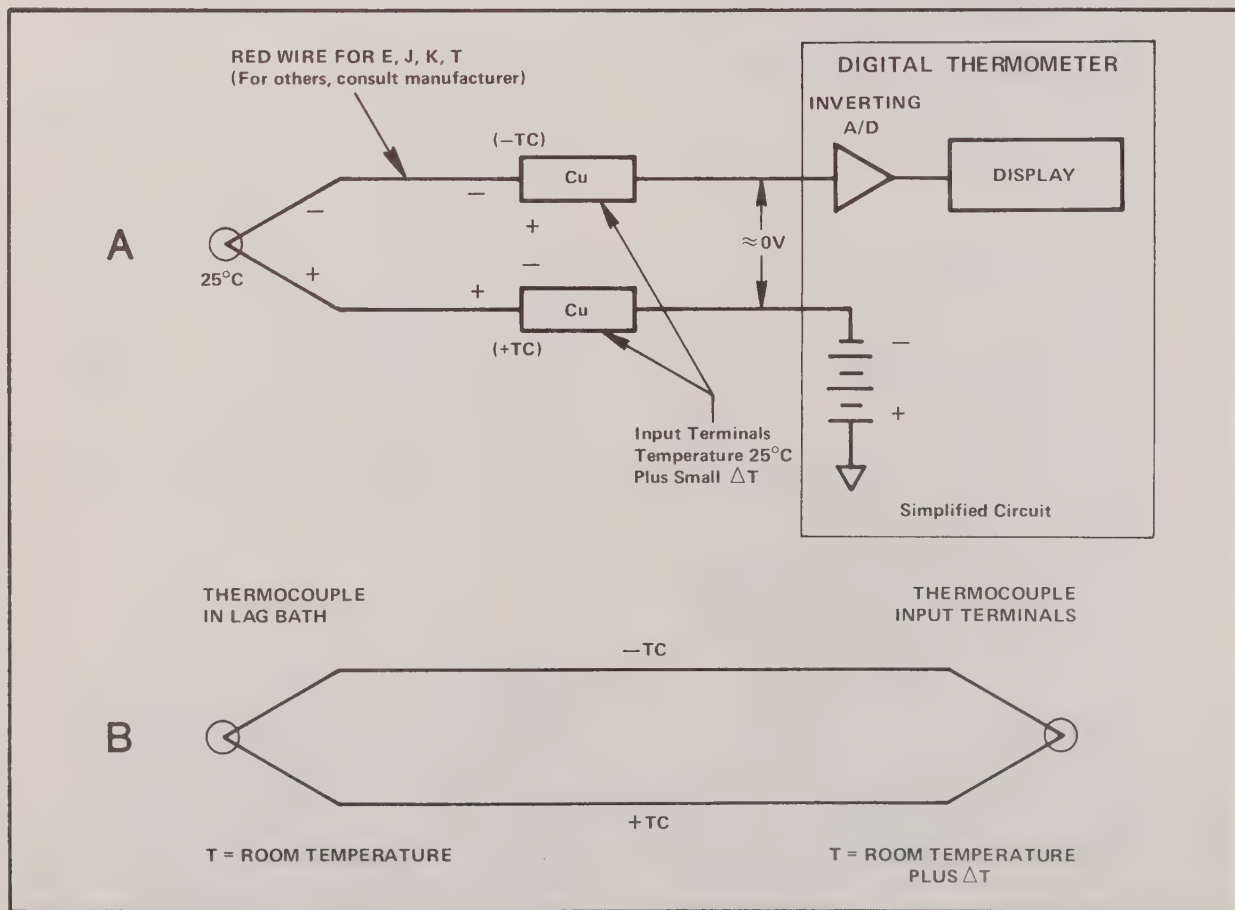


Figure 4-4. REFERENCE-JUNCTION COMPENSATION CIRCUITRY

output is zero volts. The reference-junction circuitry supplies a compensating voltage to the instrument such that the instrument will read 25°C . When calibrating the reference junction using the lag-bath technique, the reference junction is adjusted so that the instrument reads the lag-bath temperature. In using the lag-bath technique, there is only a small temperature difference, ΔT , between the thermocouple junction in the probe and the equivalent thermocouple junction formed at the input terminals of the instrument. The voltage output across the thermocouple circuit is proportional to the temperature difference, ΔT , between the two junctions. Hence, since ΔT is small, there is a small input voltage applied to the input of the instrument. This small input voltage will represent ΔT accurately to within less than $.1^{\circ}\text{F}$. Therefore, when the reference junction is calibrated so that the instrument reads lag-bath temperature, the error introduced by the thermocouple will be less than $.1^{\circ}\text{F}$.

4-43. Over-all Accuracy

4-44. The instrument will read very accurately around room temperature (See paragraph 4-41) but as the mea-

sured temperature increases or decreases from room temperature, the amount of thermocouple output deviation from NBS Standard 125, becomes the limiting factor in the accuracy of the instrument. If the thermocouple is in error by $+4^{\circ}\text{F}$, at 900°F the display will be $+4^{\circ}\text{F}$ higher than if the thermocouple conformed perfectly to NBS Standard 125. Error specifications for the instrument do not include thermocouple probe inaccuracies. Those errors must be added to the instrument error in order to obtain an over-all accuracy figure.

4-45. TROUBLESHOOTING

4-46. A troubleshooting guide for the thermometer is given in Table 4-7. The guide is a simplified decision table and is recommended for use in isolating a problem to a functional circuit group. Details necessary to troubleshoot a fault in a functional circuit group can be derived from Section 3 Theory of Operation and Section 8 Schematic Diagrams.

Table 4-7. TROUBLESHOOTING GUIDE

STEP	INSTRUCTION	IF YES GO TO	IF NO GO TO	GO TO
1	Energize the unit and connect a short across the thermocouple input terminals.			2
2	Does the display light?	16	3	
3	Is the power fuse blown?	4	5	
4	Replace fuse.			2
5	Are all power supply voltages present; +5, +6.8, +15 and -12V dc?	7	6	
6	Repair power supply.			2
7	Are Strobe Out pulses present at pins 9, 10, 11 and 12 of U4. (Use logic common as reference.)?	10	8	
8	Is crystal operating?	10	9	
9	Replace crystal.			2
10	Are display drivers functioning?	13	11	
11	Is output data present at pins 4, 5, 6 and 7 of U4?	12	13	
12	Replace display drivers as necessary.			2
13	Are $\overline{\Delta 2}$, AZ, INT, DE+ or DE-, and CM present at U4?	14	15	
14	Display PCB defective. Repair as necessary.			2
15	U4 is defective. Replace.			2
16	Does display read approximate ambient temperature?	21	17	
17	Refer to Section 3 of this manual and use a scope to check for the presence of the waveforms shown in Figure 3-2.			18
18	Are all waveforms correct?	20	19	
19	Perform the necessary repairs to the analog circuit.			17
20	Calibrate the thermometer.			21
21	End. Thermometer is functional.			

PERFORMANCE TEST CHECKLIST

Fluke Model 2170A Digital Thermometer

Serial No. _____

Tested By _____

Date _____

Line Voltage Regulation Passed () Failed ()

Accuracy Test See Verification Tables

°F VERIFICATION TABLE (TEMPERATURE ACCURACY)

PROBE TYPE	NOMINAL TEMPERATURE °F	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	992	990.8	_____	993.2	990.4	_____	993.6
	112	110.8	_____	113.2	110.4	_____	113.6
	-28	-29.6	_____	-26.4	-30.1	_____	-25.9
	-88	-89.6	_____	-86.4	-90.1	_____	-85.9
K	999	990.6	_____	993.4	990.2	_____	993.8
	152	150.6	_____	153.4	150.2	_____	153.8
	-48	-50	_____	-46	-50.6	_____	-45.4
	-88	-90	_____	-86	-90.6	_____	-85.4
T	732	731	_____	733	730.5	_____	733.5
	72	71	_____	73	70.5	_____	73.5
	-28	-29.7	_____	-26.3	-30.9	_____	-25.1
	-88	-89.7	_____	-86.3	-90.9	_____	-86.3
E	992	990.7	_____	993.3	990.2	_____	993.8
	112	110.7	_____	113.3	110.2	_____	113.8
	-28	-29.7	_____	-26.3	-31	_____	-25
	-88	-89.7	_____	-86.3	-91	_____	-85

°F VERIFICATION TABLE (REFERENCE-JUNCTION ACCURACY)

PROBE TYPE	90-Day or 1-Year	
	Deviation Error From Room-Temperature Lag Bath	
	Maximum	Actual
J	±1.5°	
K	±2.0°	
T	±1.5°	
E	±1.5°	

PERFORMANCE TEST CHECKLIST, Cont.

Overload

Overrange Passed () Failed ()

Open Circuit Passed () Failed ()

Internal Temperature Rise <5.0°C (9.0°F) above ambient

°C VERIFICATION TABLE (TEMPERATURE ACCURACY)

PROBE TYPE	NOMINAL TEMPERATURE °C	90 DAY			1 YEAR		
		MIN.	ACTUAL	MAX.	MIN.	ACTUAL	MAX.
J	755.6	754.9	_____	756.3	754.5	_____	756.7
	44.4	43.7	_____	45.1	43.3	_____	45.5
	-44.4	-45.4	_____	-43.4	-45.6	_____	-43.2
	-77.8	-78.8	_____	-76.8	-79	_____	-76.6
K	977.8	976.7	_____	978.9	976.4	_____	979.2
	22.2	21.1	_____	23.3	20.8	_____	23.6
	-44.4	-45.6	_____	-43.2	-45.9	_____	-42.9
	-77.8	-79	_____	-76.6	-79.3	_____	-76.3
T	377.8	377.2	_____	378.4	376.9	_____	378.7
	22.2	21.6	_____	22.8	21.3	_____	23.1
	-55.6	-56.6	_____	-54.6	-57.2	_____	-54
	-77.8	-78.8	_____	-76.8	-79.4	_____	-76.2
E	977.8	976.8	_____	978.8	976.4	_____	979.2
	44.4	43.4	_____	45.5	43	_____	45.8
	-55.6	-56.6	_____	-54.6	-57.3	_____	-53.9
	-77.8	-78.8	_____	-76.8	-79.5	_____	-76.1

°C VERIFICATION TABLE (REFERENCE-JUNCTION ACCURACY)

PROBE TYPE	90-Day or 1-Year	
	Deviation Error From Room-Temperature Lag Bath	
	Maximum	Actual
J	±1.5°	
K	±1.5°	
T	±1.5°	
E	±1.5°	

Section 5

Lists of Replaceable Parts

REFERENCE DESIGNATOR	ASSEMBLY NAME/NUMBER	PART NO.	PAGE
	Digital Thermometer, Final Assembly (2170A)		5-3
A1	Thermometer Assembly	_____	
	100V ac (2170A-4010T-2)	425009	5-4
	115V ac (2170A-4010T)	421305	5-4
	230V ac (2170A-4010T-3)	425025	5-4
A1A1	Thermometer PCB Assembly (2170A-4010)	421313	5-5
A1A2	Display PCB Assembly (2170A-4021)	448944	5-8
A2	Type Select PCB Assembly	_____	5-9

5-1. INTRODUCTION

5-2. This section contains an illustrated parts breakdown of the instrument. Components are listed alpha-numerically by assembly. Electrical components are listed by reference designation and mechanical components are listed by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists include the following information:

- a. Reference Designation or Item Number.
- b. Description of each part.
- c. Fluke Stock Number.
- d. Federal Supply Code for Manufacturers. (See Appendix A for Code-to-Name list.)
- e. Manufacturer's part Number or Type.
- f. Total Quantity per assembly or component.
- g. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc. that are not always part of the instrument, or are deviations from the basic instrument mode, the REC QTY column lists the recommended quantity of the item in that particular assembly.
- h. Use Code is provided to identify certain parts that have been added, deleted or modified during production of the instrument. Each part for which a

use code has been assigned may be identified with a particular instrument serial number by consulting the Use Code Effectivity, paragraph 5-7.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

- a. Quantity
- b. FLUKE Stock Number
- c. Description
- d. Reference Designation or Item Number
- e. Printed Circuit Board Part Number
- f. Instrument model and Serial number

5-7. USE CODE EFFECTIVITY LIST

USE CODE	SERIAL NUMBER EFFECTIVITY
A	0123 to 50000
B	50000 and on.



Indicates MOS device which may be damaged by static discharge.

FINAL ASSEMBLY, 2170A

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
	DIGITAL THERMOMETER FINAL ASSEMBLY 2170A						
A1	Thermometer Assembly				1		
	100V ac (2170A-4010T-2)	425009	89536	425009			
	115V ac (2170A-4010T)	421305	89536	421305			
	230V ac (2170A-4010T-3)	425025	89536	425025			
A2	Type Select PCB Assembly				1		
	One-of-four possible type select pcb assemblies is supplied with the unit.						
	J Type Select PCB Assembly (2160A-4016)	415653	89536	415653			
	K Type Select PCB Assembly (2160A-4017)	415661	89536	415661			
	T Type Select PCB Assembly (2160A-4018)	415927	89536	415927			
	E Type Select PCB Assembly (2160A-4019)	415935	89536	415935			
1	Bezel, panel meter	394502	89536	394502	1		
2	Case, extrusion	415505	89536	415505	1		
3	Decal, front-panel	423400	89536	423400	1		
4	Decal, model	416784	89536	416784	1		
5	Decal, serial-number	416776	89536	416776	1		
6	Decal, thermocouple-type	416792	89536	416792	1		
7	Insulator	415513	89536	415513	1		
8	Lens, plastic	413716	89536	413716	1		
9	Pawl, cast	407437	89536	407437	1		

A1 THERMOMETER ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1	THERMOMETER ASSEMBLY				REF		
	100V ac (2170A-4010T-2)	425009	89536	425009			
	115V ac (2170A-4010T)	421305	90536	421305			
	230V ac (2170A-4010-3T)	425025	89536	425025			
A1A1	Thermometer PCB Assembly (2170A-4010)	421313	89536	421313	1		
A1A2	Display PCB Assembly (2170A-4021)	448944	89536	448944	1		
T1	Transformer, power				1		
	100V ac (2160A-6512)	421032	89536	421032			
	115V ac (2160A-6510)	421057	89536	421057			
	230V ac (2160A-6511)	421040	89536	421040			
U4	IC, LSI digital P-MOS 	403527	70203	C-10186	1		
	Cord and plug, ac line	102822	70703	PH-70	1	1	
	Cord Power (230V)	343780	89536	343780	1	1	
	Panel, rear	413799	89536	413799	1		

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1A1	THERMOMETER PCB ASSEMBLY (2170A-4010) Figure 8-1	421313	89536	421313	REF		
C1	Cap, cer, .01 uF $\pm 20\%$, 3kV	266320	56289	41C301A2	1		
C3, C4	Cap, elect, 100 uF $-10/+100\%$, 25V	416982	89536	416982	2	1	
C5	Cap, elect, 4000 uF $+100/-10\%$, 10V	330761	25088	B41010-4700/10	1	1	
C6,C7, C14, C19	Cap, Ta, 10 uF $\pm 20\%$, 20V	330662	56289	196D106X0020 JA1	4		
C8	Cap, mica, 100 pF $\pm 1\%$, 500V	226126	71234	DM15F100F	1		
C9	Cap, mylar, 0.47 uF $\pm 10\%$, 100V	369124	73445	C280MA/HA470 K	1		
C10	Cap, disc, 100 pF $\pm 10\%$, 1kV	105593	71590	DD101	1		
C11	Cap, Ta, 2.2 uF $\pm 10\%$, 15V	364216	56289	196D222X9015 H1A	1		
C12	Cap, cer, .025 uF $\pm 20\%$, 100V	168435	56289	C023B101H253 M	1		
C13	Cap, polypro, 0.47 uF $\pm 10\%$, 50V	363085	89536	363085	1		
C15	Cap, cer, 2700 pF $\pm 20\%$, 100V	362889	72982	8121-A100-W5R 272M	1		
C16, C20	Cap, cer, 1000 pF $\pm 10\%$, 500V	357806	56289	C106B102G102 K	2		
C17	Cap, var, 0.25 - 1.5 pF, 2kV	218206	72982	530-000	1	1	
C18	Cap, cer, 1 pF ± 0.25 pF, 100V	436477	72982	8101-A100-C0G- 109G	1		
CR1, CR2	Diode, bridge rectifier	418582	50044	VM08	2	1	
CR4, CR5	Diode, Si, 150 mA, 75V	203323	07910	1N4448	2	1	
F1	Fuse, slo-blo, 1/16A	163030	71400	MDL1-16	1	5	
J1	Connector, female, 18-pin	435024	00779	583773-8	1		

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
Q1 thru Q6,Q8, Q9, Q12, Q14	Xstr, J-FET, N-channel	343830	89536	343830	10	2	
Q7	Xstr, Si, NPN	329698	07263	2N2484	1	1	
Q10	Xstr, FET, dual N-channel	439703	89536	439703	1	1	
Q11, Q15	Xstr, Si, NPN	218396	04713	2N3904	2	1	
Q13	Xstr, FET, dual N-channel	379321	89536	379321	1	1	
R1	Res, comp, 430 $\pm 5\%$, $\frac{1}{2}W$	109058	01121	EB4315	1		
R3	Res, mf, 15.8k $\pm 1\%$, 1/8W	293688	91637	MFF1-81582F	1		
R4, R6	Res, var, 25k $\pm 20\%$, $\frac{1}{2}W$	285213	71450	190PC253B	2	1	
R5	Res, mf, 261k $\pm 1\%$, 1/8W	257535	91637	MFF1-82613F	1		
R7	Res, mf, 187k $\pm 1\%$, 1/8W	257469	91637	MFF1-81873F	1		
R8	Res, mf, 2k $\pm 0.1\%$, 1/8W	340174	91637	MFF1-82001BS	1		
R9	Res, mf, 1k $\pm 0.1\%$, 1/8W	340380	91637	MFF1-81001BS	1		
R10	Res, comp, 47k $\pm 5\%$, 1W	150219	01121	GB4735	1		
R11, R29	Res, comp, 1M $\pm 5\%$, $\frac{1}{4}W$	182204	01121	CB1055	2		
R12	Res, mf, 26.7k $\pm .1\%$, 1/8W	344465	91637	MFF1-82672BS	1		
R13	Res, mf, 150k $\pm 1\%$, 1/8W	241083	91637	MFF1-81503F	1		
R15	Res, var, 50k $\pm 20\%$, $\frac{1}{2}W$	330688	71450	190PC504B	1	1	
R16, R17	Res, mf, 14.7k $\pm 1\%$, 1/8W	226225	91637	MFF1-81473F	2		
R18	Res, comp, 470 $\pm 5\%$, $\frac{1}{4}W$	147983	01121	CB4715	1		
R20	Res, mf, 28.7k $\pm 1\%$, 1/8W	235176	91637	MFF1-82872F	1		
R21	Res, mf, 61.9k $\pm 1\%$, 1/8W	237230	91637	MFF1-86192F	1		
R22	Res, mf, 19.1k $\pm 1\%$, 1/8W	234963	91637	MFF1-81912F	1		
R23	Res, mf, 1k $\pm 1\%$, 1/8W	168229	91637	MFF1-81001F	1		

A1A1 THERMOMETER PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
R24, R25	Res, mf, 82.5k $\pm 1\%$, 1/8W	246223	91637	MFF1-88252F	2		
R26	Res, comp, 680k $\pm 5\%$, 1/4W	188433	01121	CB6845	1		
R27	Res, comp, 100 $\pm 5\%$, 1/4W	147926	01121	CB1015	1		
R28, R33	Res, comp, 220k $\pm 5\%$, 1/4W	160937	01121	CB2245	2		
R30, R31, R32	Res, comp, 20k $\pm 5\%$, 1/4W	221614	01121	CB2035	3		
R34 thru R37	Res, comp 27k $\pm 5\%$, 1/4W	148148	01121	CB2735	4		
U1	IC, dual opnl ampl	404087	49956	RC4739DP	1	1	
U2	IC, opnl ampl	352195	49956	RC311DN	1	1	
U5	IC, TTL, bcd-to-7 segment decoder driver	340109	01295	SN7447	1	1	
U6	IC, C-MOS, Hex Buffer/Inverter 	381830	02735	CD4050AE	1	1	
U8	IC, linear, voltage regulator, +15V	413187	12040	LM340T-18	1	1	
U9	IC, linear, voltage regulator, -12V	381665	04713	MC7912CP	1	1	
VR1	Diode, zener, 6.4V $\pm 2\%$	393579	04713	1N4567	1	1	
VR2	Diode, zener, 6.8V	260695	07910	1N754A	1	1	
Y1	Crystal, 400 kHz	403352	89536	403352	1		
1	Connector, post pin	267633	00779	86144-1	8		
2	Header	417030	00779	87230-8			
3	Isothermal Block						
	Insulator	415695	89536	415695	1		
	Plate, terminal, neg	415687	89536	415687	1		
	Plate, terminal, pos	415679	89536	415679	1		
4	Socket, IC, 40-pin	418988	91506	340-AG37D	1		

A1A2 DISPLAY PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A1A2	DISPLAY PCB ASSEMBLY (2170A-4021) Figure 8-3	448944	89536	448944	REF		
DS1, DS2	LED, dual 7-segment character display	419051	29083	MAN 6610	2	1	A
DS3	LED, 7-segment character display	407874	29083	MAN 4610	1	1	A
DS1 thru DS5	LED, 7-segment numeric display	418012	28480	5082-7651	5	1	B
Q1 thru Q4	Xstr, Si, Darlington NPN	381798	04713	MPS A-13	4	1	
R1	Res, comp, $91 \pm 5\%$, $\frac{1}{4}W$	221887	01121	CB9105	1		
R2	Res, comp, $62 \pm 5\%$, $\frac{1}{4}W$	261842	01121	CB6205	1		
U1	IC, res network, 60Ω	344069	89536	344069	1	1	
	Socket	376418	22526	75060-007	6		

A2 TYPE SELECT PCB ASSEMBLY

REF DESIG OR ITEM NO.	DESCRIPTION	FLUKE STOCK NO.	MFG FED SPLY CDE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	USE CDE
A2	TYPE SELECT PCB ASSEMBLY				REF		
	Figure 8-5						
	J Type (2160A-4016)	415653	89536	415653			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 10.7k $\pm 1\%$, 1/8W	423681	91637	MFF1-81072F	1		
R2	Res, mf, 619 $\pm 0.1\%$, 1/8W	423715	91637	MFF1-86190B	1		
	K Type (2160A-4017)	415661	89536	415661			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 3.74k $\pm 1\%$, 1/8W	260547	91637	MFF1-83741F	1		
R2	Res, mf, 481.4 $\pm 0.1\%$, 1/8W	423723	91637	MFF1-8481R4B	1		
	T Type (2160A-4018)	415927	89536	415927			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 3.74k $\pm 1\%$, 1/8W	260547	91637	MFF1-83741F	1		
R2	Res, mf, 483.7 $\pm 0.1\%$, 1/8W	423731	91637	MFF1-8483R7B	1		
	E Type (2160A-4019)	415935	89536	415935			
P3	Socket, IC, 8-pin	418608	00779	583640-1	1		
R1	Res, mf, 53.6k $\pm 1\%$, 1/8W	291401	91637	MFF1-85362F	1		
R2	Res, mf, 732 $\pm 0.1\%$, 1/8W	423749	91637	MFF1-87320B	1		

Section 6

Option & Accessory Information

6-1. INTRODUCTION

6-2. This section of the manual contains information concerning the Options and Accessories available for use with the Model 2170A Digital Thermometer. The first portion of this section provides a brief description of each option and accessory. The depth of detail is intended to give the prospective user an adequate first acquaintance with the features and capabilities of each. Detailed information concerning specifications, operating instructions, maintenance, list of replaceable parts, and schematics is supplied separately with some options and accessories, and is designed to comprise the second portion of this section. Unique page and paragraph numbering is assigned to each of the add-on descriptions to allow separation into easily identifiable subsections. The material is prepunched (T-punched) to permit insertion without disassembling the manual. Table 6-1 lists the available options and accessories and defines the manner in which each is documented.

6-3. THERMOCOUPLE PROBES

6-4. Three types of thermocouple probe assemblies (J, K and T) are available from Fluke for use with the 2170A. See Table 6-1. Each thermocouple is enclosed in a 6-inch x 1/8 inch iconel sheath, and includes a heavy duty transition splice and spring. See Figure 6-1. The thermocouple junction is grounded to the sheath, and 36-inch trimmed leads are included on all units. Refer to the Tables under Specifications in Section 1 of this manual for the temperature ranges recommended for each thermocouple type.

6-5. RACK MOUNTING PANELS

6-6. Three rack-mounting panels are available for mounting the 2170A in a standard 19-inch equipment rack. The panels, listed in Table 6-1, provide the option of mounting

either one, two or three units. Panel mounting instructions for the 2170A are given in Section 2 of this manual.

Table 6-1. 2170A OPTIONS, ACCESSORIES AND DOCUMENTATION SOURCES

MODEL OR OPTION NO.	DESCRIPTION	DOCUMENTATION SUPPLIED	
		WITH UNIT	HERE IN
P20J	J-Type TC Probe		●
P20K	K-Type TC Probe		●
P20T	T-Type TC Probe		●
2160A-7031	Rack Mtg. Panel, 1 unit		●
2160A-7032	Rack Mtg. Panel, 2 units		●
2160A-7033	Rack Mtg. Panel, 3 units		●
2160A-7016	J-Type Select PCB		●
2160A-7017	K-Type Select PCB		●
2160A-7019	E-Type Select PCB		●
2160A-7018	T-Type Select PCB		●
2160A-7022	Interface Cable		●
2161A	Multipoint Selector	○	
2162A	Digital Comparator	○	
-02	Digital Output Unit	○	
-04	Analog Output Unit	○	

○ = T-punched for insertion in Section 6 of this manual

● = Not T-punched

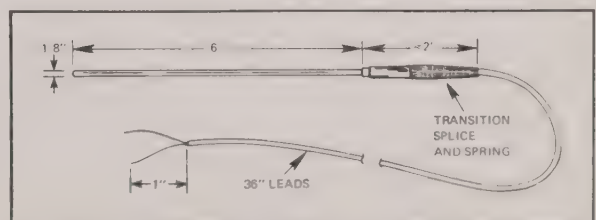


Figure 6-1. P20 SERIES THERMOCOUPLE PROBES

6-7. TYPE SELECT PCB'S

6-8. A series of plug-in type select pcb's are available as accessories to allow the thermocouple compatibility of the 2170A to be changed by the user. The available pcb's are listed in Table 6-1, and the instructions necessary to interchange pcb's in the 2170A are given in Section 2 of this manual under Thermocouple Compatibility. Only one of the pcb's can be installed in the 2170A at any given time.

6-9. MODEL 2161A MULTIPOINT SELECTOR

6-10. The Model 2161A Multipoint Selector is a panel-mounting, manually-switched selector that allows 1-of-10 thermocouple probes (all of the same type) to function as the thermocouple input to the 2170A. When more than 10 inputs are involved, 2 or more 2161A's can be stacked in either a serial or parallel configuration.

6-11. MODEL 2162A DIGITAL COMPARATOR

6-12. The Model 2162A Digital Comparator is a panel-mounting, manually-set, single-limit comparator. Front-panel, thumb-wheel switches provide for the selection of high or low ($>$ or $\leq$), polarity and four limit digits. The resolution of the 2162A is $\pm 1^\circ$. A cable on the rear of the 2162A attaches to the back of the 2170A to provide the 2162A with both operating voltage and display data. When an out-of-limit reading occurs at the 2170A, the 2162A generates both a visual and an electrical indication, i.e., a front-panel LED is lit and a contact closure occurs. The contact closure is accessible through the 2162A's rear panel, and is electrically

isolated from both the 2170A and the 2162A. Two 2162A's can be connected in parallel for multiple limit requirements.

6-13. DIGITAL OUTPUT UNIT, OPTION -02

6-14. The Digital Output Unit (Option -02) is a field installable pcb that mounts on the interior of the 2170A and provides a digital output which is equivalent to the displayed measurement data. The digital output is positive-true, TTL compatible and is presented in bcd, character-parallel format. All displayed characters are represented at the output. Output data is solicited by an External Trigger input and valid data is ensured by Busy and $\overline{\text{Busy}}$ outputs.

6-15. External connections to the Digital Output Unit are made through a 34-pin cable which is supplied with the pcb.

6-16. ANALOG OUTPUT UNIT, OPTION -04

6-17. The Analog Output Unit is a field installable pcb assembly which provides the 2170A with a rear-panel analog output voltage proportional to the displayed measurement data. The output voltage is electrically isolated from the 2170A and covers a voltage range of -0.4 to $+4\text{V dc}$. Automatic polarity sensing is provided for both $^\circ\text{C}$ and $^\circ\text{F}$ measurements to ensure that the polarity of the output voltage agrees with the displayed polarity. Since the analog output terminals are isolated from the 2170A, the output voltage is referenced to the low terminal of the external recording device (voltmeter, strip-chart recorder, etc.).

6-18. External connections to the Analog Output Unit are made through a connector and cable which is supplied with the pcb.

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable parts contained in Section 5. The following information is presented in this section:

List of Abbreviations

Federal Supply Codes for Manufacturers

Fluke Technical Service Centers — U.S. and Canada

Sales and Service Locations — International

Sales Representatives — U.S. and Canada

List of Abbreviations and Symbols

A or amp	ampere	H	henry	pF	picofarad
ac	alternating current	hd	heavy duty	pn	part number
af	audio frequency	hf	high frequency	(+) or pos	positive
a/d	analog-to-digital	Hz	hertz	pot	potentiometer
assy	assembly	IC	integrated circuit	p-p	peak-to-peak
AWG	american wire gauge	if	intermediate frequency	ppm	parts per million
B	bel	in	inch(es)	PROM	programmable read-only memory
bcd	binary coded decimal	intl	internal	psi	pound-force per square inch
°C	Celsius	I/O	input/output	RAM	random-access memory
cap	capacitor	k	kilo (10^3)	rf	radio frequency
ccw	counterclockwise	kHz	kilohertz	rms	root mean square
cer	ceramic	k Ω	kilohm(s)	ROM	read-only memory
cermet	ceramic to metal(seal)	kV	kilovolt(s)	s or sec	second (time)
ckt	circuit	lf	low frequency	scope	oscilloscope
cm	centimeter	LED	light-emitting diode	SH	shield
cmrr	common mode rejection ratio	LSB	least significant bit	Si	silicon
comp	composition	LSD	least significant digit	Serno	serial number
cont	continue	M	mega (10^6)	sr	shift register
crt	cathode-ray tube	m	milli (10^{-3})	Ta	tantalum
cw	clockwise	mA	milliampere(s)	tb	terminal board
d/a	digital-to-analog	max	maximum	tc	temperature coefficient or temperature compensating
dac	digital-to-analog converter	mf	metal film	tcxo	crystal oscillator
dB	decibel	MHz	megahertz	tp	test point
dc	direct current	min	minimum	u or μ	micro (10^{-6})
dmm	digital multimeter	mm	millimeter	uhf	ultra high frequency
dvm	digital voltmeter	ms	millisecond	us or μ s	microsecond(s) (10^{-6})
elect	electrolytic	MSB	most significant bit	uut	unit under test
ext	external	MSD	most significant digit	V	volt
F	farad	MTBF	mean time between failures	v	voltage
°F	Fahrenheit	MTTR	mean time to repair	var	variable
FET	Field-effect transistor	mV	millivolt(s)	vco	voltage controlled oscillator
ff	flip-flop	mv	multivibrator	vfh	very high frequency
freq	frequency	M Ω	megohm(s)	vlf	very low frequency
FSN	federal stock number	n	nano (10^{-9})	W	watt(s)
g	gram	na	not applicable	ww	wire wound
G	giga (10^9)	NC	normally closed	xfmr	transformer
gd	guard	(-) or neg	negative	xstr	transistor
Ge	germanium	NO	normally open	xtal	crystal
GHz	gigahertz	ns	nanosecond	xtlo	crystal oscillator
gmV	guaranteed minimum value	opnl ampl	operational amplifier	Ω	ohm(s)
gnd	ground	p	pico (10^{-12})	μ	micro (10^{-6})
		para	paragraph		
		pcb	printed circuit board		

Federal Supply Codes for Manufacturers (Continued)

00213 Nytronics Comp. Group Inc. Subsidiary of Nytronics Inc. Formerly Sage Electronics Rochester, New York	03797 Eldema Div. Genisco Technology Corp. Compton, California	05574 Viking Industries Chatsworth, California	07597 Burndy Corp. Tape/Cable Div. Rochester, New York
00327 Welwyn International, Inc. Westlake, Ohio	03877 Transistron Electronic Corp. Wakefield, Massachusetts	05704 Replaced by 16258	07792 Lerma Engineering Corp. Northampton, Massachusetts
00656 Aerovox Corp. New Bedford, Massachusetts	03888 KDI Pyrofilm Corp. Whippany, New Jersey	05820 Wakefield Engineering Inc. Wakefield, Massachusetts	07910 Teledyne Semiconductor Formerly Continental Device Hawthorne, California
00686 Film Capacitors, Inc. Passaic, New Jersey	03911 Clairex Electronics Div. Clairex Corp. Mt. Vernon, New York	06001 General Electric Co. Electronic Capacitor & Battery Products Dept. Columbia, South Carolina	07933 - use 49956 Raytheon Co. Semiconductor Div. HQ Mountain View, California
00779 AMP Inc. Harrisberg, Pennsylvania	03980 Muirhead Inc. Mountainside, New Jersey	06136 Replaced by 63743	08225 Industro Transistor Corp. Long Island City, New York
01121 Allen-Bradley Co. Milwaukee, Wisconsin	04009 Arrow Hart Inc. Hartford, Connecticut	06383 Panduit Corp. Tinley Park, Illinois	08261 Spectra Strip Corp. Garden Grove, California
01281 TRW Electronic Comp. Semiconductor Operations Lawndale, California	04062 Replaced by 72136	06473 Bunker Ramo Corp. Amphenol SAMS Div. Chatsworth, California	08530 Reliance Mica Corp. Brooklyn, New York
01295 Texas Instruments, Inc. Semiconductor Group Dallas, Texas	04202 Replaced by 81312	06555 Beede Electrical Instrument Co. Penacook, New Hampshire	08806 General Electric Co. Miniature Lamp Products Dept. Cleveland, Ohio
01537 Motorola Communications & Electronics Inc. Franklin Park, Illinois	04217 Essex International Inc. Wire & Cable Div. Anaheim, California	06739 Electron Corp. Littleton, Colorado	08863 Nylomatic Corp. Norrisville, Pennsylvania
01686 RCL Electronics Inc. Manchester, New Hampshire	04221 Aemco, Div. of Midtex Inc. Mankato, Minnesota	06743 Clevite Corp. Cleveland, Ohio	08988 - use 53085 Skottie Electronics Inc. Archbald, Pennsylvania
01730 Replaced by 73586	04222 AVX Ceramics Div. AVX Corp. Myrtle Beach, Florida	06751 Components, Inc. Semcor Div. Phoenix, Arizona	09214 G.E. Co. Semi-Conductor Products Dept. Power Semi-Conductor Products OPN Sec. Auburn, New York
01884 - use 56289 Sprague Electric Co. Dearborn Electronic Div. Lockwood, Florida	04423 Telonic Industries Laguna Beach, California	06860 Gould Automotive Div. City of Industry, California	09353 C and K Components Watertown, Massachusetts
02114 Ferroxcube Corp. Saugerties, New York	04645 Replaced by 75376	06961 Vernitron Corp., Piezo Electric Div. Formerly Clevite Corp., Piezo Electric Div. Bedford, Ohio	09423 Scientific Components, Inc. Santa Barbara, California
02131 General Instrument Corp. Harris ASW Div. Westwood, Maine	04713 Motorola Inc. Semiconductor Products Phoenix, Arizona	06980 Eimac Div. Varian Associates San Carlos, California	09922 Burndy Corp. Norwalk, Connecticut
02395 Rason Mfg. Co. Brooklyn, New York	04946 Standard Wire & Cable Los Angeles, California	07047 Ross Milton, Co., The South Hampton, Pennsylvania	09969 Dale Electronics Inc. Yankton, S. Dakota
02533 Snelgrove, C.R. Co., Ltd. Don Mills, Ontario, Canada M3B 1M2	05082 Replaced by 94988	07115 Replaced by 14674	10059 Barker Engineering Corp. Formerly Amerace, Amerace ESNA Corp. Kenilworth, New Jersey
02606 Fenwal Labs Div. of Travenal Labs. Morton Grove, Illinois	05236 Jonathan Mfg. Co. Fullerton, California	07138 Westinghouse Electric Corp., Electronic Tube Division Horsehead, New York	11236 CTS of Berne Berne, Indiana
02660 Bunker Ramo Corp., Conn Div. Formerly Amphenol-Borg Electric Corp. Broadview, Illinois	05245 Components Corp. now Corcom, Inc. Chicago, Illinois	07233 TRW Electronic Components Cinch Graphic City of Industry, California	11237 CTS Keene Inc. Paso Robles, California
02799 Aero Capacitors, Inc. Chatsworth, California	05277 Westinghouse Electric Corp. Semiconductor Div. Youngwood, Pennsylvania	07256 Silicon Transistor Corp. Div. of BBF Group Inc. Chelmsford, MA	11358 CBS Electronic Div. Columbia Broadcasting System Newburyport, MN
03508 General Electric Co. Semiconductor Products Syracuse, New York	05278 Replaced by 43543	07261 Aumet Corp. Culver City, California	11403 Best Products Co. Chicago, Illinois
03614 Replaced by 71400	05279 Southwest Machine & Plastic Co. Glendora, California	07263 Fairchild Semiconductor Div. of Fairchild Camera & Instrument Corp. Mountain View, California	11503 Keystone Columbia Inc. Warren, Michigan
03651 Replaced by 44655	05397 Union Carbide Corp. Materials Systems Div. New York, New York	07344 Bircher Co., Inc. Rochester, New York	11532 Teledyne Relays Hawthorne, California
	05571 - use 56289 Sprague Electric Co. Pacific Div. Los Angeles, California		

Federal Supply Codes for Manufacturers (Continued)

11711 General Instrument Corp Rectifier Division Hickville, New York	14099 Semtech Corp. Newbury Park, California	17069 Circuit Structures Lab. Burbank, California	24655 General Radio Concord, Massachusetts
11726 Qualidyne Corp. Santa Clara, California	14140 Edison Electronic Div. Mc Gray-Edison Co. Manchester, New Hampshire	17338 High Pressure Eng. Co., Inc. Oklahoma City, Oklahoma	24759 Lenox-Fugle Electronics Inc. South Plainfield, New Jersey
12014 Chicago Rivet & Machine Co. Bellwood, Illinois	14193 Cal-R-Inc. formerly California Resistor, Corp. Santa Monica, California	17545 Atlantic Semiconductors, Inc. Asbury Park, New Jersey	25088 Siemen Corp. Isilen, New Jersey
12040 National Semiconductor Corp. Danbury, Connecticut	14298 American Components, Inc. an Insilco Co. Conshohocken, Pennsylvania	17856 Siliconix, Inc. Santa Clara, California	25403 Amperex Electronic Corp. Semiconductor & Micro-Circuits Div. Slatersville, Rhode Island
12060 Diodes, Inc. Chatsworth, California	14655 Cornell-Dublier Electronics Division of Federal Pacific Electric Co. Govt. Control Dept. Newark, New Jersey	17870 Replaced by 14140	27014 National Semiconductor Corp. Santa Clara, California
12136 Philadelphia Handle Co. Camden, New Jersey	14752 Electro Cube Inc. San Gabriel, California	18178 Vactec Inc. Maryland Heights, Missouri	27264 Molex Products Downers Grove, Illinois
12300 Potter-Brumfield Division AMF Canada LTD. Guelph, Onatrio, Canada	14869 Replaced by 96853	18324 Signetics Corp. Sunnyvale, California	28213 Minnesota Mining & Mfg. Co. Consumer Products Div. St. Paul, Minnesota
12323 Presin Co., Inc. Shelton, Connecticut	14936 General Instrument Corp. Semi Conductor Products Group Hicksville, New York	18612 Vishay Resistor Products Div. Vishay Intertechnology Inc. Malvern, Pennsylvania	28425 Serv./-Link formerly Bohannon Industries Fort Worth, Texas
12327 Freeway Corp. formerly Freeway Washer & Stamping Co. Cleveland, Ohio	15636 Elec-Trol Inc. Saugus, California	18736 Voltronics Corp. Hanover, New Jersey	28478 Deltrol Controls Div. Deltrol Corporation Milwaukee, Wisconsin
12443 Budd Co. The, Polychem Products Plastic Products Div. Bridgeport, PA	15801 Fenwal Electronics Inc. Div. of Kidde Walter and Co., Inc. Framingham, Massachusetts	18927 G T E Sylvania Inc. Precision Material Group Parts Division Titusville, Pennsylvania	28480 Hewlett Packard Co. Corporate H.Q. Palo Alto, California
12615 U.S. Terminals Inc. Cincinnati, Ohio	15818 Teledyne Semiconductors, formerly Amelco Semiconductor Mountain View, California	19451 Perine Machinery & Supply Co. Seattle, Washington	28520 Heyman Mfg. Co. Kenilworth, New Jersey
12617 Hamlin Inc. Lake Mills, Wisconsin	15849 Litton Systems Inc. Useco Div. formerly Useco Inc. Van Nuys, California	19701 Electro-Midland Corp. Mepco-Electra Inc. Mineral Wells, Texas	29083 Monsanto, Co., Inc. Santa Clara, California
12697 Clarostat Mfg. Co. Dover, New Hampshire	15898 International Business Machines Corp. Essex Junction, Vermont	20584 Enochs Mfg. Inc. Indianapolis, Indiana	29604 Stackpole Components Co. Raleigh, North Carolina
12749 James Electronics Chicago, Illinois	15909 Replaced by 14140	20891 Self-Organizing Systems, Inc. Dallas, Texas	30148 A B Enterprise Inc. Ahoskie, North Carolina
12856 Micrometals Sierra Madre, California	16258 Space-Lok Inc. Burbank, California	21604 Buckeye Stamping Co. Columbus, Ohio	30323 Illinois Tool Works, Inc. Chicago, Illinois
12954 Dickson Electronics Corp. Scottsdale, Arizona	16299 Corning Glass Electronic Components Div. Raleigh, North Carolina	21845 Solitron Devices Inc. Transistor Division Riveria Beach, Florida	31091 Optimax Inc. Colmar, Pennsylvania
12969 Unitrode Corp. Watertown, Massachusetts	16332 Replaced by 28478	22767 ITT Semiconductors Palo Alto, California	32539 Mura Corp. Great Neck, New York
13103 Thermalloy Co., Inc. Dallas, Texas	16473 Cambridge Scientific Ind. Div. of Chemed Corporation Cambridge, Maryland	23050 Product Comp. Corp. Mount Vernon, New York	32767 Griffith Plastic Corp. Burlingame, California
13327 Solitron Devices Inc. Tappan, New York	16742 Paramount Plastics Fabricators, Inc. Downey, California	23732 Tracor Inc. Rockville, Maryland	32879 Advanced Mechanical Components Northridge, California
13511 Amphenol Cadre Div. Bunker-Ramo Corp. Los Gatos, California	16758 Delco Electronics Div. of General Motors Corp. Kokomo, Indiana	23880 Stanford Applied Engrng. Santa Clara, California	32897 Erie Technological Products, Inc. Frequency Control Div. Carlisle, Pennsylvania
13606 - use 56289 Sprague Electric Co. Transistor Div. Concord, New Hampshire	17001 Replaced by 71468	23936 Pamotor Div., Wm. J. Purdy Co. Burlingame, California	32997 Bourns Inc. Trimpot Products Division Riverside, California
13839 Replaced by 23732		24248 Replaced by 94222	33173 General Electric Co. Products Dept. Owensboro, Kentucky
		24355 Analog Devices Inc. Norwood, Massachusetts	

Federal Supply Codes for Manufacturers (Continued)

34333 Silicon General Westminister, California	70563 Amperite Company Union City, New Jersey	73293 Hughes Aircraft Co. Electron Dynamics Div. Torrence, California	77969 Rubbercraft Corp. of CA. LTD. Torrance, California
34335 Advanced Micro Devices Sunnyvale, California	70903 Belden Corp. Geneva, Illinois	73445 Amperex Electronic Corp. Hicksville, LI, New York	78189 Shakeproof Div. of Illinois Tool Works Inc. Elgin, Illinois
34802 Electromotive Inc. Kenilworth, New Jersey	71002 Birnbach Radio Co., Inc. Freeport, LI New York	73559 Carling Electric Inc. West Hartford, Connecticut	78277 Sigma Instruments, Inc. South Braintree, Massachusetts
37942 Mallory, P.R. & Co., Inc. Indianapolis, Indiana	71400 Bussmann Mfg. Div. of McGraw-Edison Co. Saint Louis, Missouri	73586 Circle F Industries Trenton, New Jersey	78488 Stackpole Carbon Co. Saint Marys, Pennsylvania
42498 National Radio Melrose, Massachusetts	71450 CTS Corp. Elkhart, Indiana	73734 Federal Screw Products, Inc. Chicago, Illinois	78553 Eaton Corp. Engineered Fastener Div. Tinnerman Plant Cleveland, Ohio
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Section 8

Schematic Diagrams

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8-6	A2 Type Select PCB Assembly Schematic	(2160A-1012)	8-6

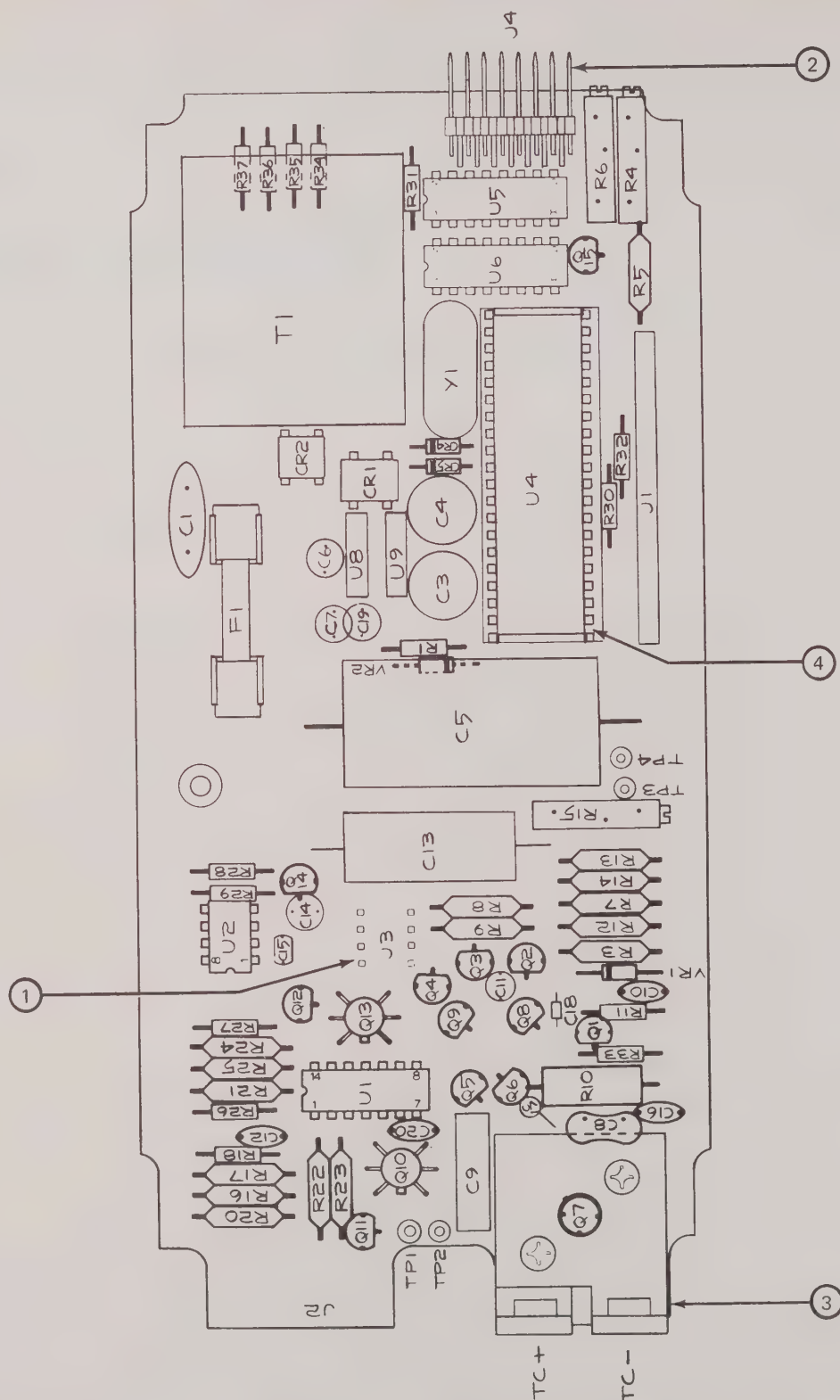
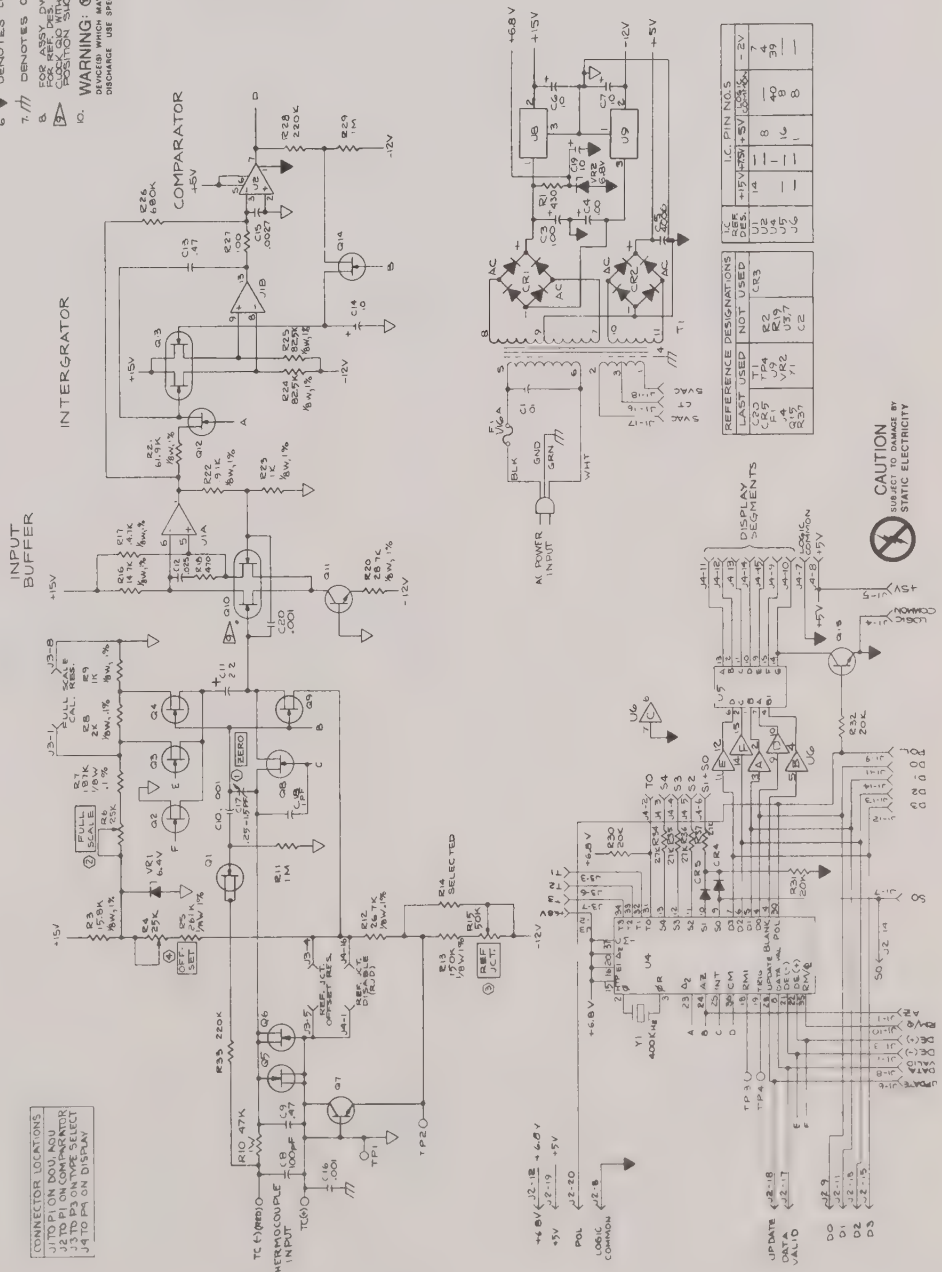


Figure 8-1. A1A1 THERMOMETER PCB ASSEMBLY COMPONENT LOCATION (2170A-1610)

- NOTES
1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN PICOFARADS.
 2. $\bigcirc$ DENOTES CALIBRATION ADJ. POINTS. ALL POINTS ARE ZEROED AFTER ADJUST.
 3. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED.
 4. ALL GRAPHIC SYMBOLS IN ACCORDANCE WITH ANSI Y32.1A AND Y32.2.
 5. ∇ DENOTES ANALOG COMMON.
 6. $\blacktriangledown$ DENOTES LOGIC COMMON.
 7. $\text{---}/\text{---}$ DENOTES CHASSIS COMMON.
 8. FOR ASSY PWS SEE 2170A-4010.
 9. FOR ASSY PWS SEE 2170A-4010.
 10. COCKED POSITION WITH MARKED GATE IN POSITION SHOWN.
 11. WARNING: $\odot$ INDICATES USAGE OF 100K DIVIDER WHICH MAY BE DAMAGED BY EXCESSIVE VOLTAGE. USE PARTIAL INSULATION PER 810P 18.7



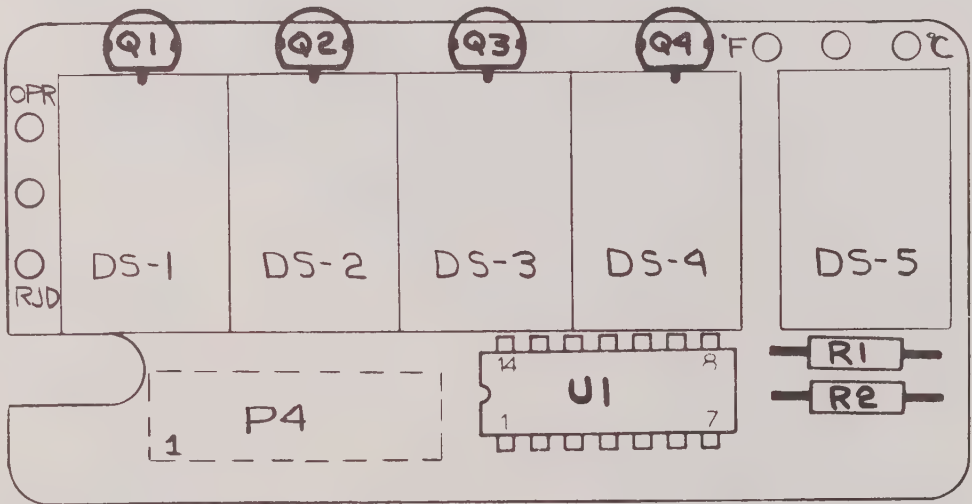
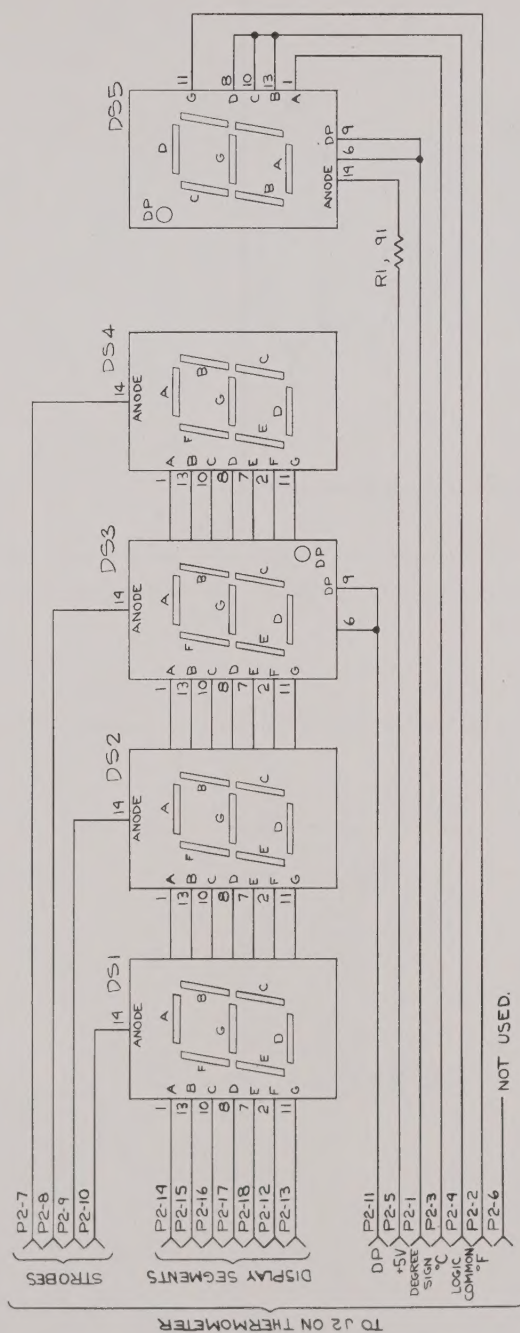


Figure 8-3. A1A2 DISPLAY PCB ASSEMBLY COMPONENT LOCATION (2170A-1621)



NOTES:

1. UNLESS OTHERWISE SPECIFIED ALL RESISTANCES ARE IN OHMS AND ALL CAPACITANCES ARE IN MICROFARADS.
2. ○ DENOTES CALIBRATION ADJ. POINTS. ALL POINTS ARE SERVO-DRIVER ADJUST.
3. ALL RESISTORS ARE 1/4W, 5% UNLESS OTHERWISE NOTED.
4. ALL GRAPHIC SYMBOLS IN ACCORDANCE WITH ANSI Y32.14 AND Y32.2.

Figure 8-4. A1A2 DISPLAY PCB ASSEMBLY SCHEMATIC (2160A-1021)

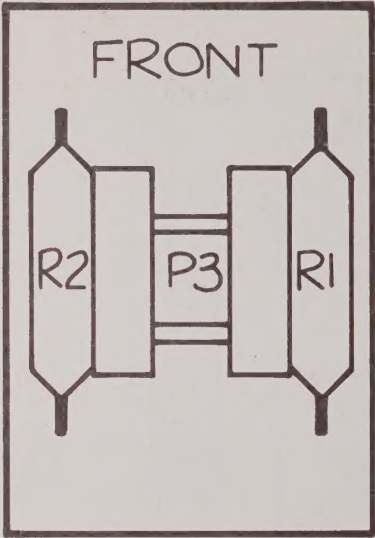


Figure 8-5. A2 TYPE SELECT PCB ASSEMBLY COMPONENT LOCATION (2160A-1612)

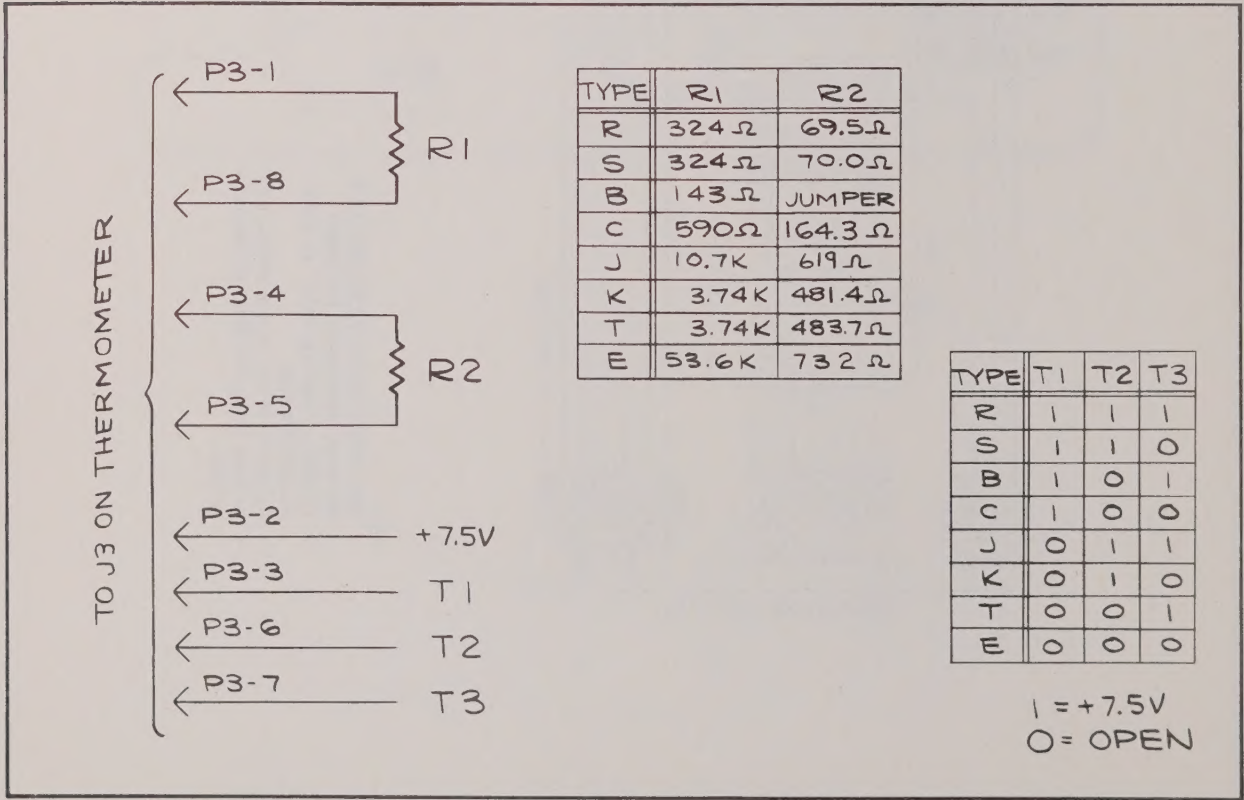


Figure 8-6. A2 TYPE SELECT PCB ASSEMBLY SCHEMATIC (2160A-1012)

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